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FINAL REPORT

CATALYTIC METHODS USING MOLECULAR OXYGEN FOR TREATMENT OF PMMS & ECLSS WASTE STREAMS

Volume II

UMPQUA RESEARCH COMPANY

FINAL REPORT

CATALYTIC METHODS USING MOLECULAR OXYGEN FOR TREATMENT OF PMMS & ECLSS WASTE STREAMS

Volume II

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APPENDIX A

PERFORMANCE OF CATALYTIC OXIDATION IN STAGE 4/5 TESTING AT MSFC

A breadboard catalytic oxidation system was delivered to the NASA/Marshall Space Flight Center in March of 1991 for use in the ongoing Phase III CMIF Water Recovery Tests. The system was integrated into a Potable Water Recovery System which was assembled to evaluate the performance of various water reclamation technologies on simulated Space Station Freedom wastewater. The various waste streams were generated in the End-use Equipment Facility (EEF), a clean room that houses the equipment needed to provide the simulated wastewaters. The equipment includes a shower, laundry, microwave, urine collection device, and exercise equipment. Makeup air provided to the EEF is missile grade air, which has a near zero level of humidity, particulates, and organic constituents. The missile grade air is fed to the EEF at a rate that will maintain a carbon dioxide level in the EEF below 1.0% and minimize leakage into the EEF from the outside. This condition ensures that the condensate collected in the EEF is metabolic or hygiene condensate, with minimal contamination from the EEF surroundings (1). The major components of the multifiltration subsystem are the sterilization assembly and unibed train (see Figure A1). A schematic of the breadboard catalytic oxidation system is shown in Figure A2. This assembly was added as a posttreatment process to provide the capability to meet the potable TOC specification of 500 ppb. The integrated system was tested from 6/06/91 to 7/17/91. The wastewater challenges include humidity condensate and hygiene water. A 5% Ru, 2.5% Pt on activated carbon was used in this system (the performance of this catalyst was described earlier.)

The humidity condensate feed supplied by the EEF initially passes

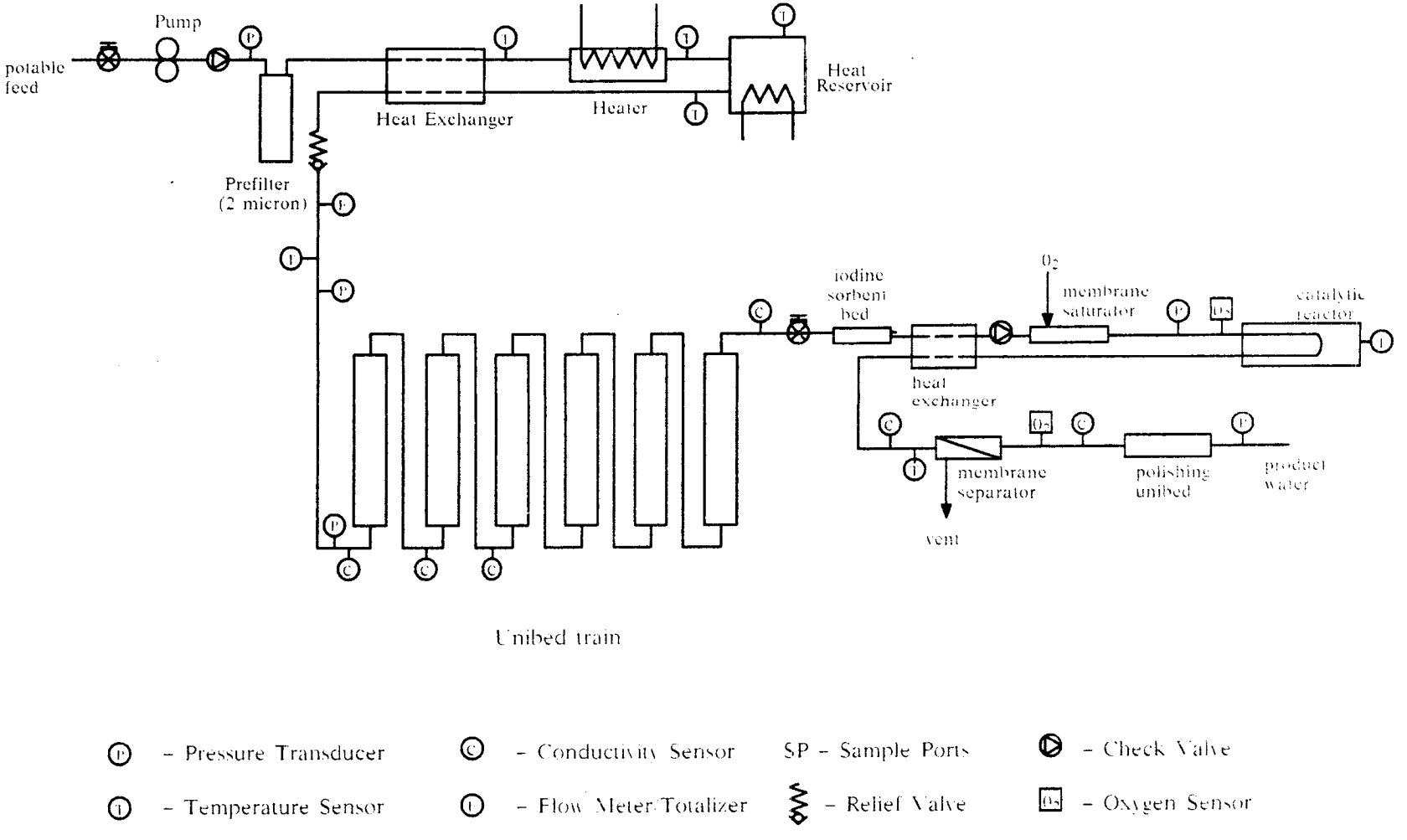
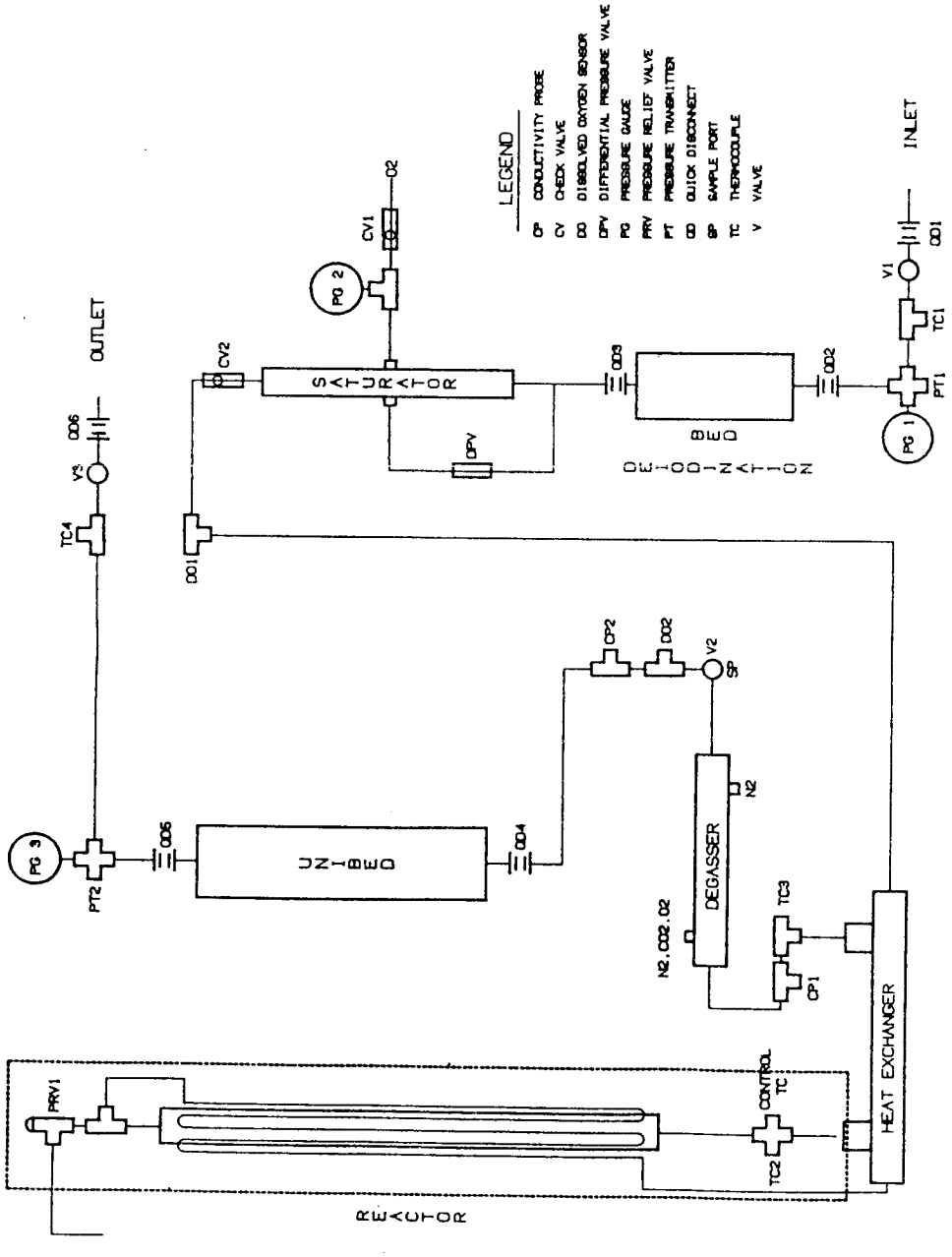


FIGURE A1. WRT Stage 4/5 Potable Multifiltration with VRA Posttreatment Schematic



CATALYTIC OXIDATION BREADBOARD SYSTEM

FIGURE A2

through a 2.0 micron prefilter and the sterilization assembly, where the sterilizer reservoir maintains a temperature of 121° C for twenty minutes, thus achieving sterilization conditions. The unibed train consists of six identical unibeds in series. Further information on unibeds and their design is available in Reference 2. The breadboard catalytic oxidation system (known as the Volatile Removal Assembly (VRA) at MSFC) receives the effluent from the unibed train, which first passes through an iodine sorbent bed to prevent iodine from degrading the catalyst's performance. The process stream is saturated with oxygen by a membrane saturator, which receives oxygen gas at a pressure of 18-30 psig, nominally 4-8 psi below the water pressure. The organics are oxidized in the reactor with the reaction by-products subsequently removed in the membrane separator (carbon dioxide) and the polishing unibed (organic acids). The membrane separator is also used to remove excess oxygen not utilized in the reactor.

The breadboard catalytic oxidation system performed as expected during Stage 4/5. Instrumentation and laboratory data show that the various components functioned effectively. Questionable data was provided by an oxygen sensor located at the effluent of the membrane saturator. However, the performance of the assembly in terms of TOC removal indicates that the saturator was providing adequate oxygen levels. The temperature required in the reactor for oxidation, 125° C, (257° F) was maintained throughout testing.

The concentration of oxygen in the effluent from the membrane degasser was nominally less than 5 mg/l and never exceeded the oxygen saturation level of 8.2 mg/l at STP (Potable Water Quality Specification for free gas). Since the CO_2 level out of the degasser was not measured, the

effectiveness of the degasser on CO_2 removal during this test cannot be concluded.

The breadboard catalytic oxidation system provided effective removal of organic contaminants not removed by the multifiltration unibed technology. A summary of the data on significant analytes detected during the test is provided in Table A1. The outlet data is for samples drawn after the degasser and prior to the posttreatment bed. The major contaminants in the feed were ethanol, methanol, and propylene glycol. The influent TOC averaged 5180 ppb. Though these and other contaminants were detected in the effluent on a few occasions, the TOC content of the effluent averaged 370 ppb and was below the potable specification of 500 ppb on 20 out of 23 test days (see Figure A3). TOC characterization of the specific organics in the effluent indicates the their reported values may be high since the characterized TOC was higher than the measured TOC on several days.

Additional testing was completed subsequent to the completion of the test objectives to evaluate the compatibility of catalytic oxidation with hygiene feed (waste shower, handwash, laundry and urine distillate) through unibeds designed for processing a waste hygiene feed. The water quality of the product hygiene (from tank 4) is summarized in Table A2. Approximately 37 lbs of the feed was processed through the potable catalytic oxidation assembly over a 21 hour period. Product water samples were pulled approximately every two hours immediately after the degasser. TOC levels below the potable specification were routinely met during the test (see Figure A4), as were all other specifications upon which analysis was performed. The data shows that the organics present in the product hygiene

TABLE A1
WRT S. 4/5 VRA Results

PARAMETER/TEST DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
INLET																							
CONDUCTIVITY															2.79	46.1	2.02	1.9	2.23	3.92	1.62	2.51	1.74
pH															7.5	4	6.6	7	7.5	6.2	7.1	7.4	7.8
TOC															3.19	5.32	5.52	6.16	7.16	4.56	5.4	4.9	4.36
ACETIC ACID															0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
PROPIONIC ACID															0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
ETHANOL															2.54	3.7	4	5.34	6.31	5.13	3.67	2.33	2.06
METHANOL															0.41	1.5	1.33	0.41	1.16	1.49	1.42	1.42	1.27
PROPYLENE GLYCOL															3.17	3.72	4.16	4.42	2.67	2.85	2.89	2.04	2.81
ETHYLENE GLYCOL															0.6	0.6	0.53	0.74	0.48	0.6	0.6	0.36	0.46
OUTLET																							
CONDUCTIVITY	6.22		2.3		3.2		2.03		1.98		3.42		2.75		4.67	3.7	3.09	2.52	4.36	3.42	4.66	3.45	3.56
pH	7.4		5.9		6.5		6.1		6		6.6		7		7.1	7.1	6.1	6.3	6	5.9	6.3	6.1	6
TOC	0.48	0.22	0.2	0.66	0.44	0.3	0.311	0.37	0.24	0.2	0.21	0.8	0.31	0.2	0.18	0.4	0.46	0.24	0.45	0.64	0.37	0.26	0.44
ACETIC ACID	0.16	0.16	0.16	0.52	0.24	0.166	0.16	0.16	0.16	0.16	0.16	0.12	0.16	0.16	0.16	0.16	0.16	0.17	0.16	0.16	0.16	0.16	0.16
PROPIONIC ACID	0.4	0.4	2.12	0.4	0.4	0.4	0.4	1.38	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
ETHANOL	0.1	0.1	0.1	0.1	0.1	1.72	2.28	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
METHANOL	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	041	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
PROPYLENE GLYCOL		0.25	0.25	0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.76
EHTYLENE GLYCOL		0.25	5.01	0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.32

* All values are in ppm except conductivity (umhos/cm) and pH.

FIGURE A3. WRT Stage 4/5 Potable Test
Multifiltration with VRA Posttreatment
Total Organic Carbon Results

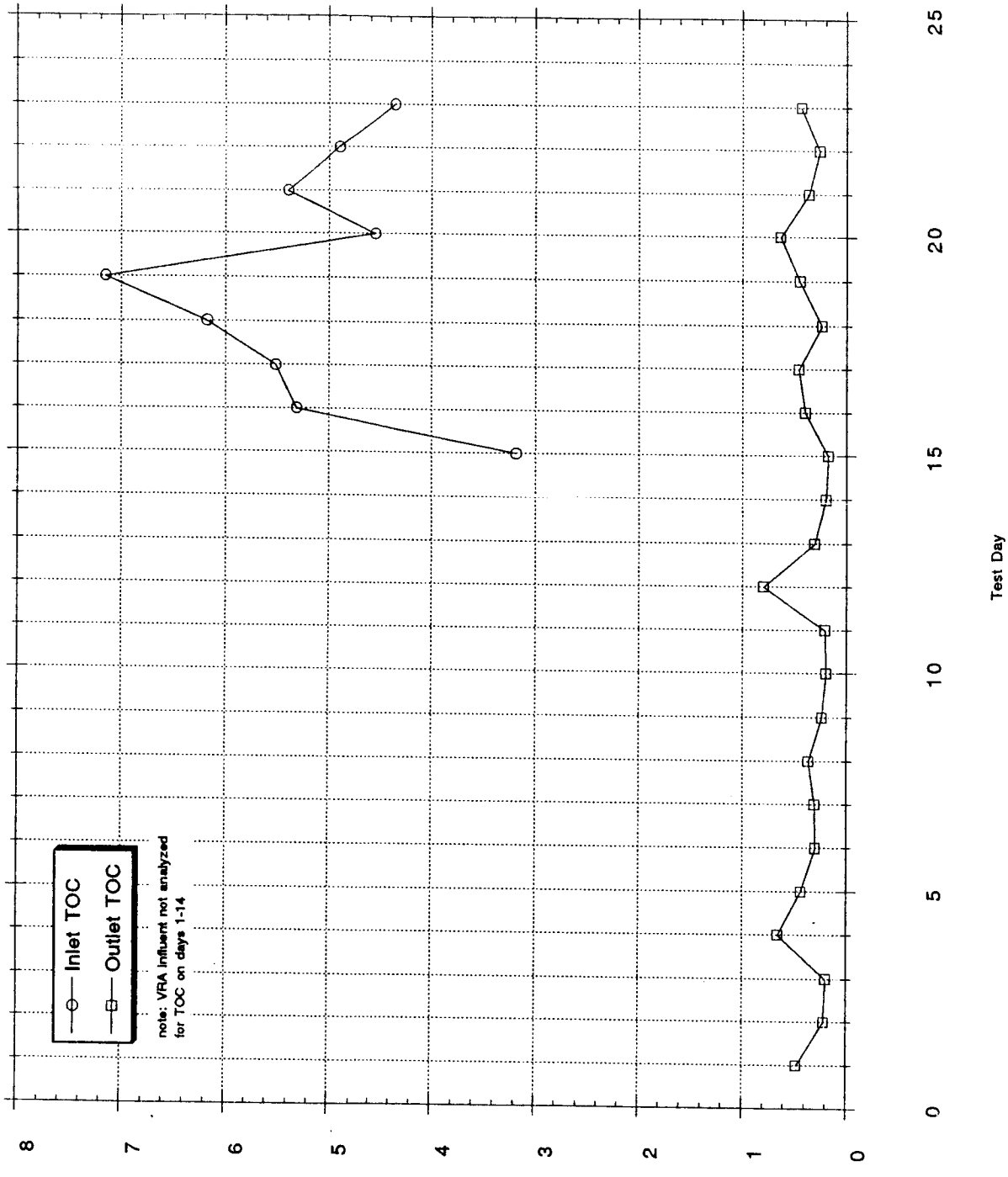
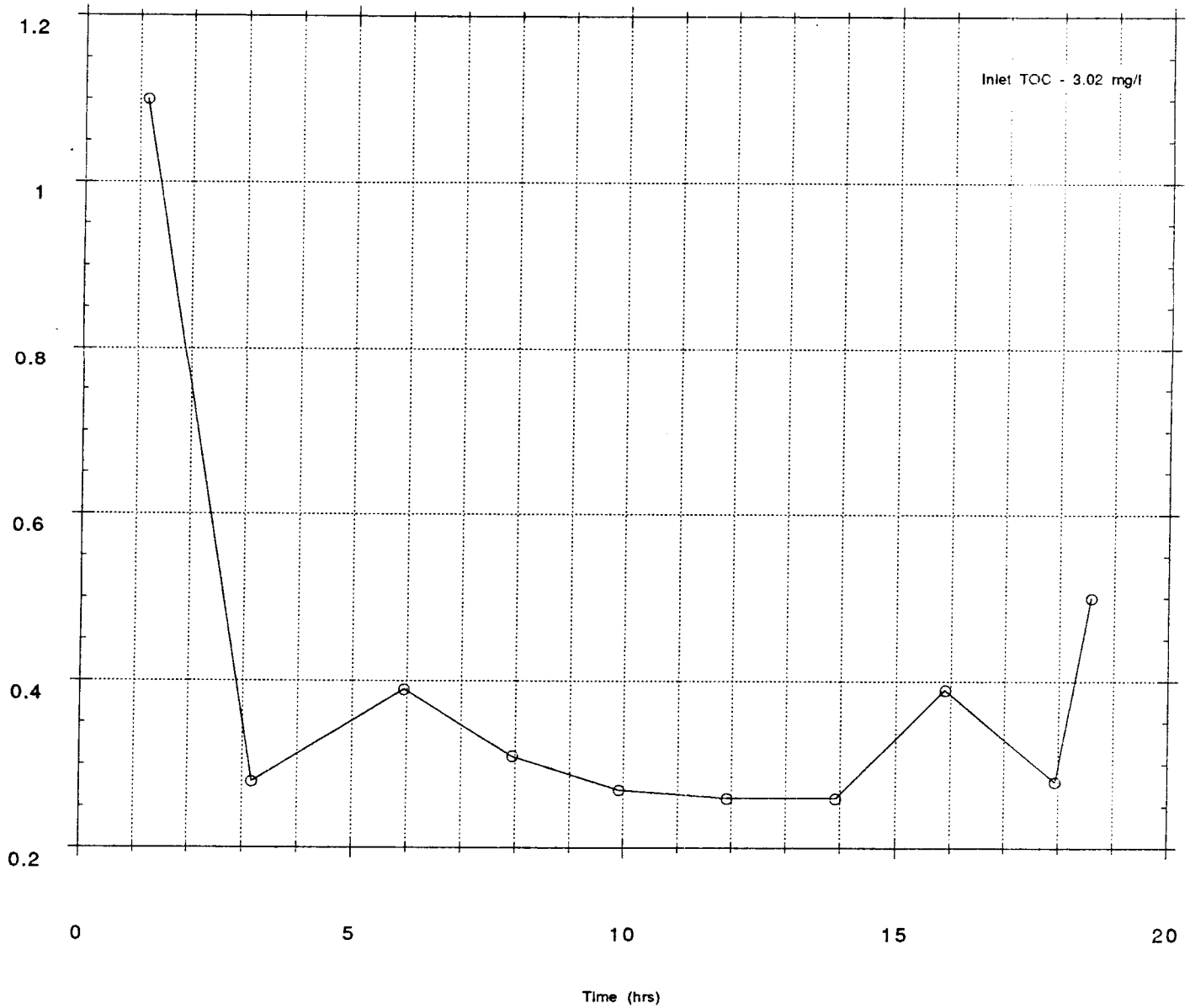


FIGURE A4. WRT Stage 4/5 Testing
VRA Posttreated Hygiene Product Water
Total Organic Carbon Results



water (mainly ethanol, methanol, and urea) were effectively removed via catalytic oxidation. The only specific organics detected in the effluent were acetone (0.04 ppm) and sulfonylbismethane (0.07 ppm). Additional testing will be necessary to determine the impact of hygiene water on the performance due to the long-term presence of contaminants specific to the hygiene loop (e.g., soaps).

TABLE A2. HYGIENE PRODUCT WATER QUALITY

(PRIOR TO VRA POSTTREATMENT)

TOC	3.02 mg/l	Conductivity	6.49 µmhos/cm
pH	7.6	Urea	7.18 mg/l
Ethanol	2.76 mg/l	Methanol	2.15 mg/l

REFERENCES

1 Traweek, M.S., R.M. Bagdigian, and G. Griffity, "Phase III Integrated WaterRecovery Testing at MSFC-Partially-Closed Hygiene Loop Results and Lessons Learned", Presented at the 21st Intersociety Conference on Environmental Systems, San Francisco, CA, July 1991

2 Putnam, D.F., et al, "Space Station Hygiene Water Reclamation by Multifiltration", Presented at the 21st Intersociety Conference on Environmental Systems, San Francisco, CA, July 1991

APPENDIX B

HARDWARE MANUAL

for

INTEGRATED CATALYTIC OXIDATION MULTIFILTRATION BREADBOARD SYSTEMS FOR TREATMENT OF PMMS AND ECLSS WASTE STREAMS

April 15, 1992

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CATALYTIC OXIDATION HARDWARE MANUAL

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I. INTRODUCTION

This manual describes the two catalytic oxidation test units fabricated in the phase II portion of contract NAS8-38490 and documents the design characteristics of the hardware.

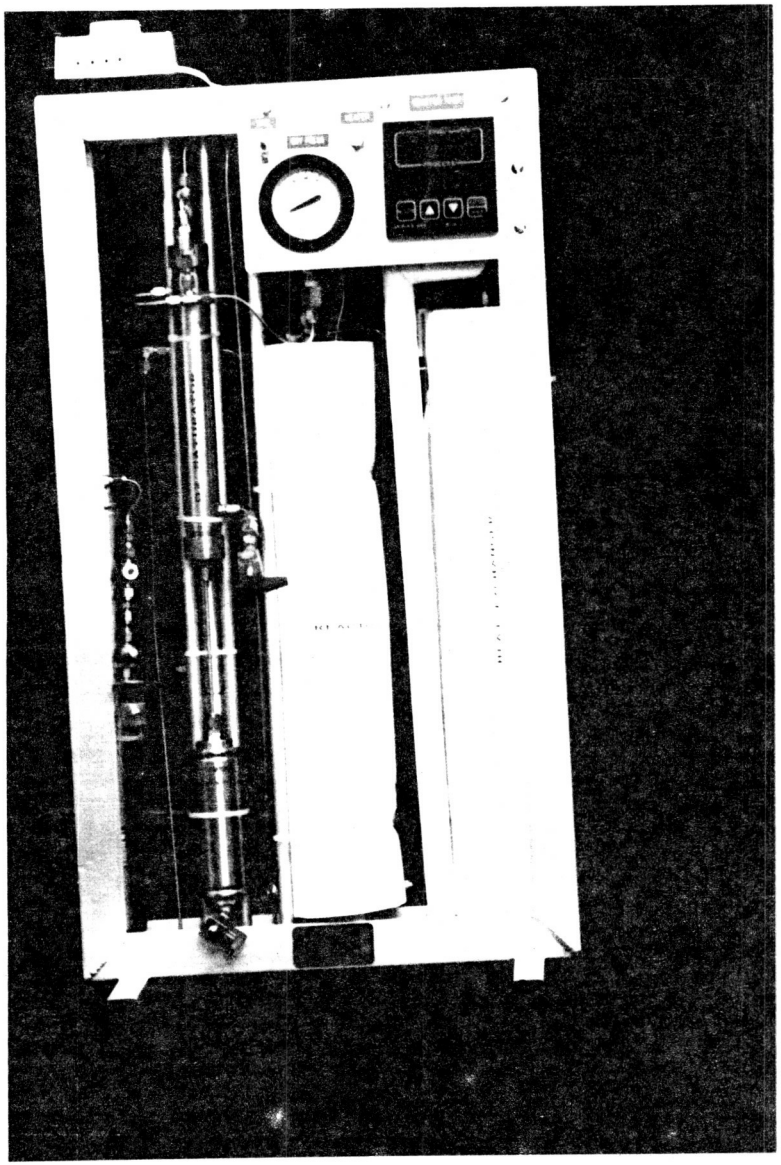
The two catalytic oxidation test units (see Fig. 1 and 2) were designed for long term performance testing with influents containing low molecular weight, non-polar organic species such as acetone and alcohols at flow rates up to 10 cc/min. These organic species are poorly removed by ion-exchange adsorption. The test units' catalytic reactors convert these species at a temperature of 121 degrees C in the presence of oxygen to gas (predominantly CO_2 which is removed by a degasser) and other oxidized forms such as organic acids which can be easily removed by adsorption techniques to meet potable water standards.

The two units differ only in the pretreatment and post-treatment of the effluent entering the catalytic oxidation portion of the equipment (see Figs. 3 and 4). A de-iodinator is used in both units to protect the catalyst from poisoning by iodine. Unit 1 has only a post conditioning adsorption bed which is designed primarily to remove SO_4^{--}, NH_4^+, and organic acids, but will also remove Ca^+, Na^+, K^+, Mg^+, Cl^-, F^-, NO_3^-. Unit 2 has a preconditioning bed designed to remove primarily ammonium ions and organic acids, but will incidentally remove those ions enumerated for unit 1 (Configuration A) above. The post conditioning bed for unit 2 (Configuration B) removes primarily SO_4^{--} and any remnant organic acids. The post treatment beds also provide residual iodine in the output water stream to provide an antimicrobial treatment.

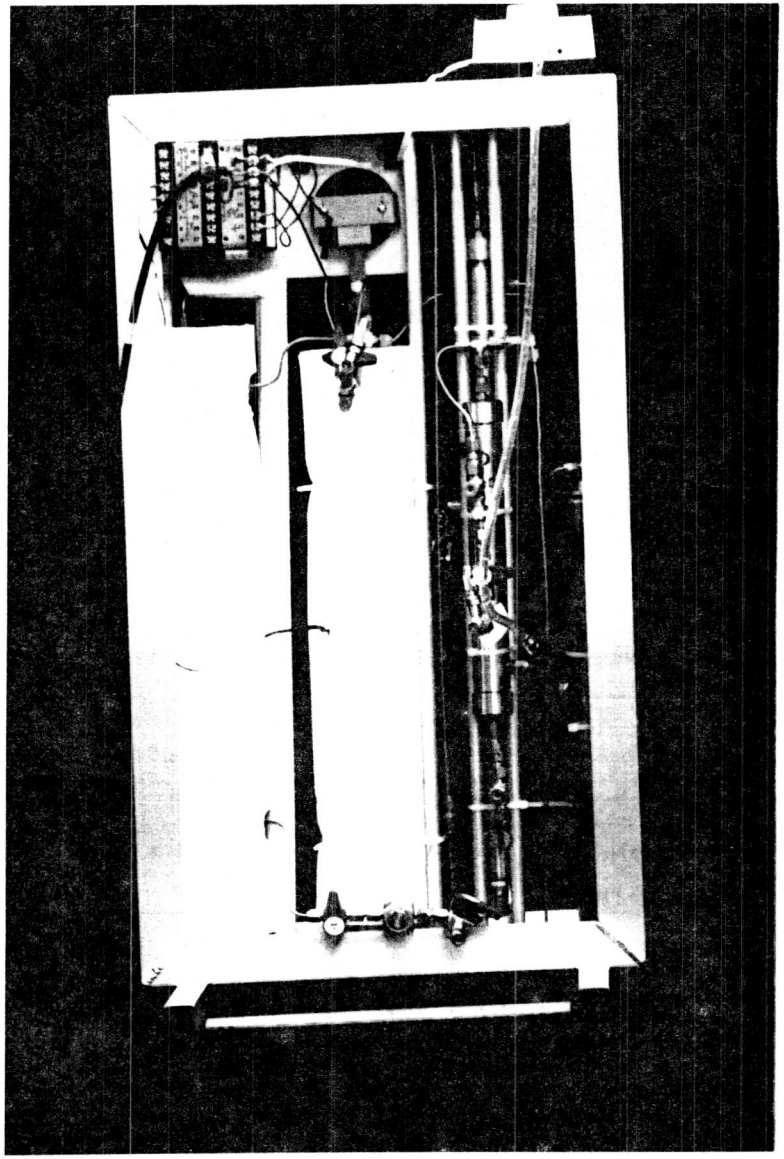
II. TECHNICAL DESCRIPTION

1. SYSTEM CONFIGURATION

The schematic diagrams for the two test units are shown in Figs. 3 and 4. (Note: the influent pump is external to the system.) The influent inters the de-iodinator at a pressure of 30 psig which will prevent a phase change below 134 degrees C. The influent flow rate is regulated by a needle valve at the exit side of the post treatment bed. Oxygen is also supplied to the saturator at a pressure of 30 psig through a 1/3 psi check valve which protects the saturator tubing from a sudden loss of oxygen pressure. A pressure gauge is provided on the unit to read oxygen pressure accurate to about 1%. A 10 psi relief valve will prevent the hydrostatic pressure from exceeding the oxygen pressure by more than 10 psi. This protects the silastic tubing in the saturator from overpressure by venting the liquid to the gas side of the microtubes.



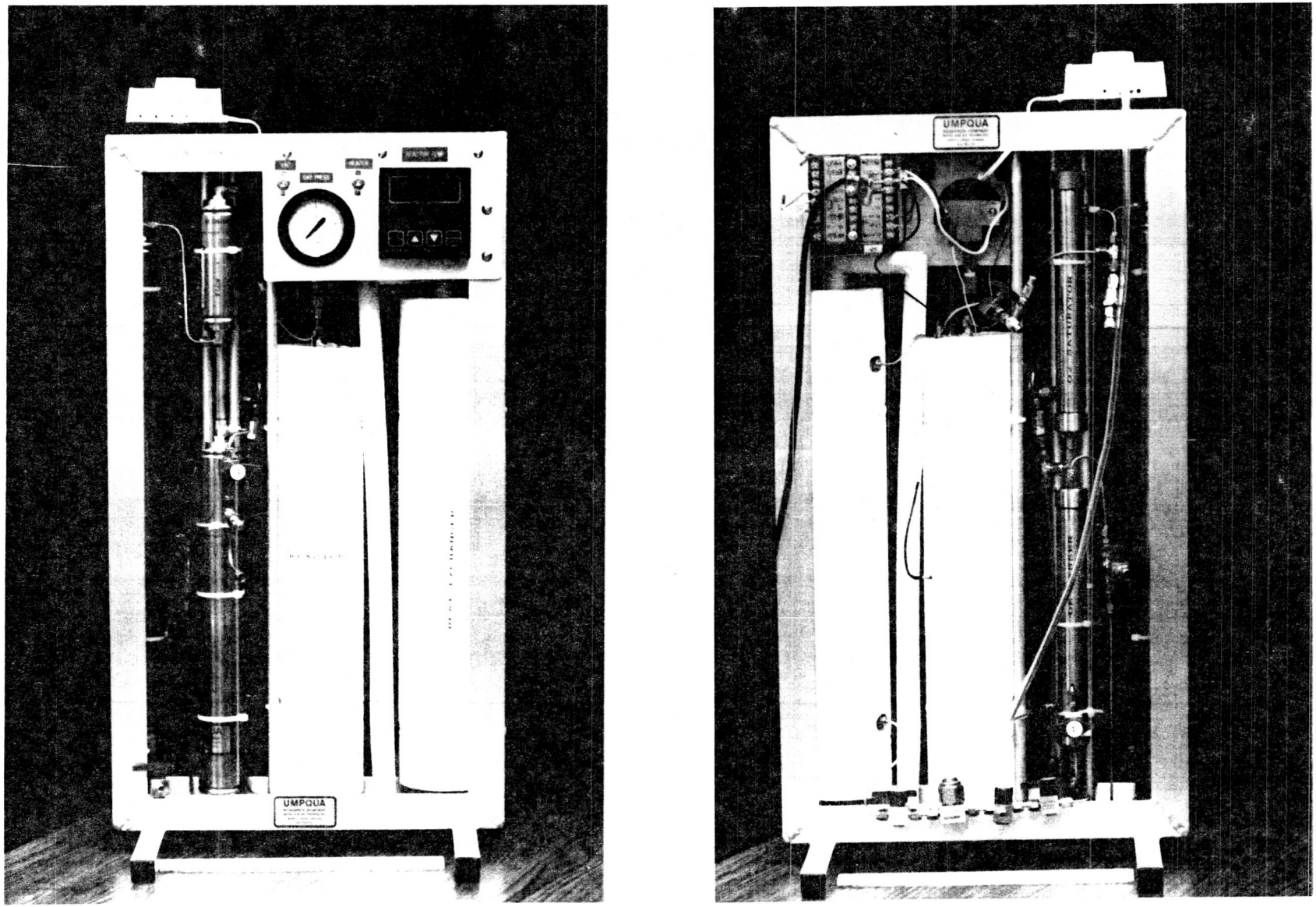
a).



b).

Figure 1. CATALYTIC OXIDATION TEST UNIT 1

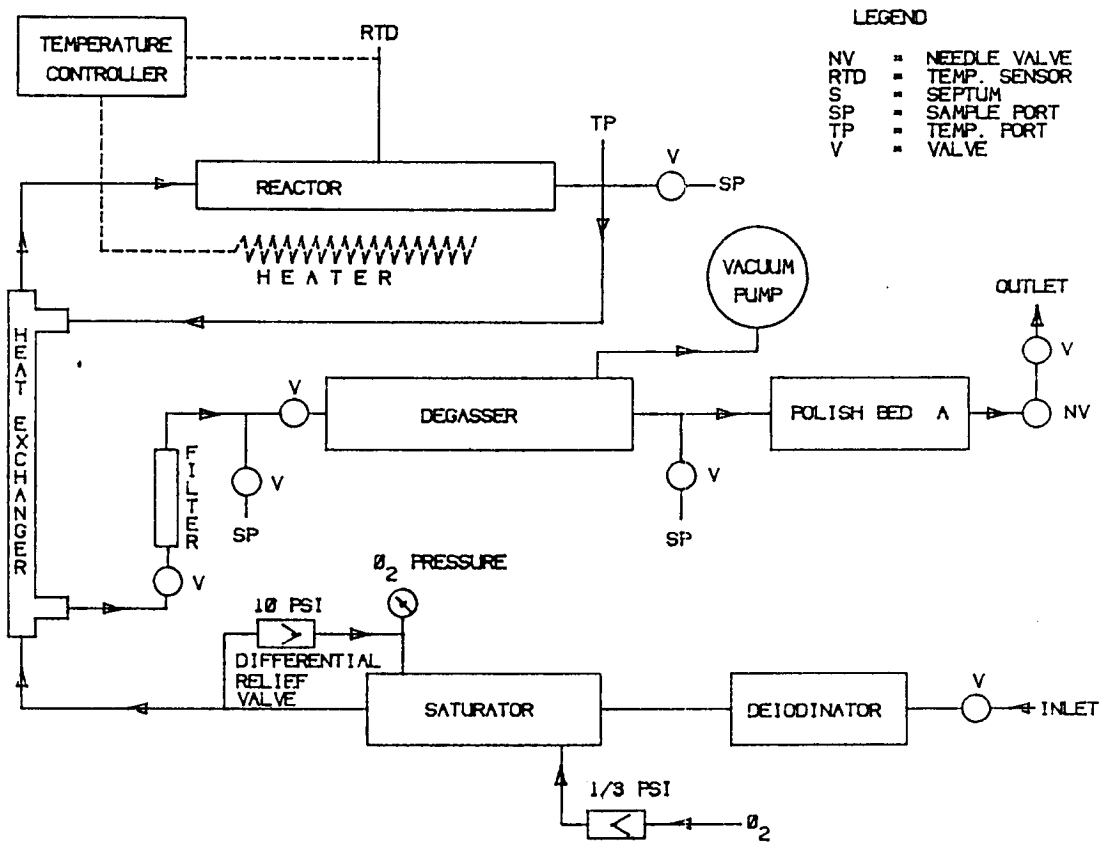
a) Front View b) Rear View



a). b).

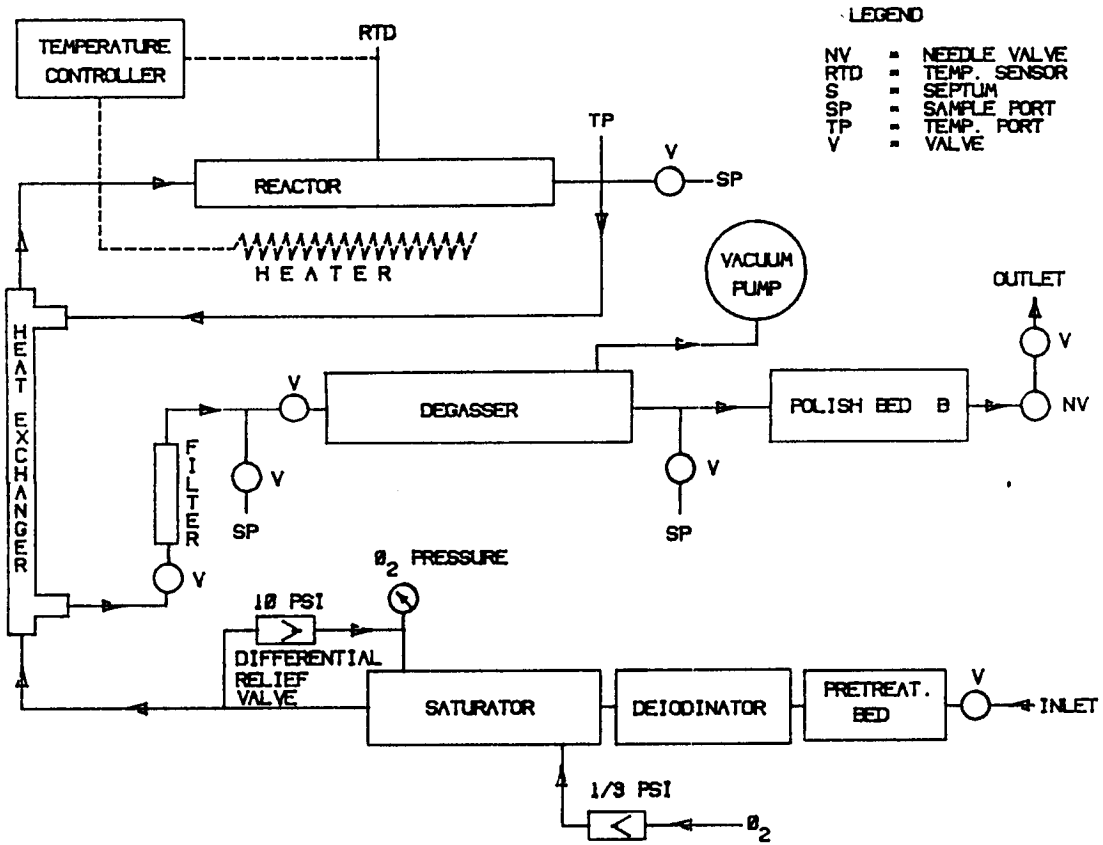
Figure 2. CATALYTIC OXIDATION TEST UNIT 2

a) Front View b) Rear View



BREADBOARD CATALYTIC OXIDATION SYSTEM

Figure 3. SCHEMATIC UNIT 1



BREADBOARD CATALYTIC OXIDATION SYSTEM

Figure 4. SCHEMATIC UNIT 2

The stream then passes through the tube side of the shell and tube heat exchanger before passing on to the catalytic reactor from which it flows back through the shell side of the heat exchanger in the counterflow direction. This preheats the effluent entering the reactor and cools the effluent to room temperature before passing through a 2.0 micron filter to the degasser. The filter prevents carbon particles from entering the degasser. An RTD at the center of the reactor senses the temperature of the effluent stream and acts as a control sensor for the Watlow PID temperature controller which provides current control to the heating element around the reactor body. This makes it possible to control the temperature at the center of the reactor to 121 degrees C plus or minus about 0.2 degrees C. A mechanical over-temperature safety switch in thermal contact with the heater opens the heating element circuit automatically at about 138 degrees C.

A small vacuum pump draws air over the degasser microtubes to keep a high concentration gradient across the membrane. The degassed effluent then passes through the polishing (post treatment) bed before exiting the system. Sampling ports (1/4 inch T-fittings) are provided at the following points,

a. Top of the reactor.
b. Before degasser.
c. After degasser.
d. Outlet

2. ACTIVE COMPONENTS

2.1 SATURATOR

The saturator provides a means of saturating the influent stream with dissolved oxygen via a silastic membrane. The Umpqua 70056-1 design (see Fig. 5) divides the saturator into two major assemblies: the outer stainless steel housing and the inner polycarbonate membrane housing. The removable inner housing is sealed within the stainless steel outer housing with viton O-rings providing separation of the liquid and gas streams. The threaded stainless steel end caps are also sealed with O-rings.The saturator is approximately 11 inches long by 1.25 inches in diameter.The inner housing is 3/4 inch I.D. by 10.5 inches long. This configuration allows easy replacement of the active membrane element as well as simplifying the construction and testing of the membrane element itself.

The membrane surface area required is a function of the influent flow rate, the dissolved gas concentration, and the gas vapor pressure external to the membrane (concentration gradient). The latter is dependent on the partial pressure of the gas across the membrane and the

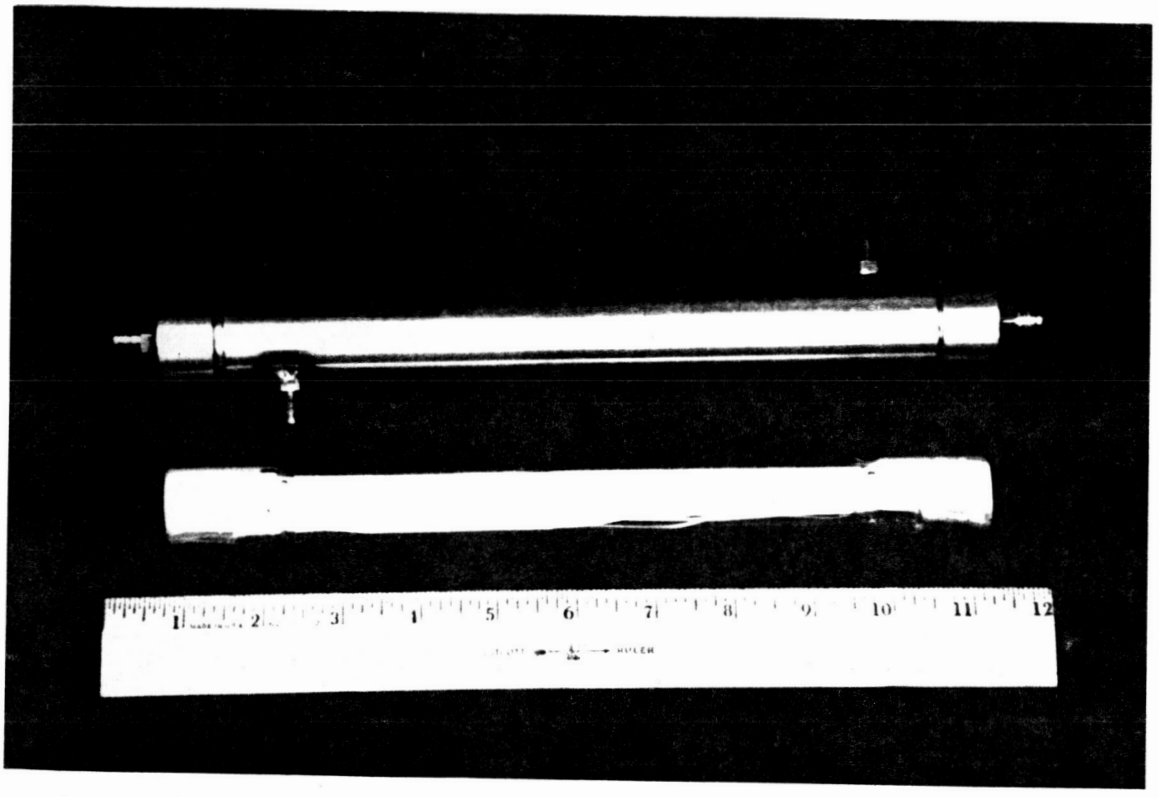


Figure 5 SATURATOR OR DEGASSER SHOWING INNER HOUSING

concentration of the gas in the liquid. The silastic microtubes which form the gas permeable membrane are 0.012 inches I.D. by 0.025 inches O.D. with an active length of about 8.5 inches. Each microtube provides about 2 square centimeters of active membrane surface for the diffusion of oxygen into the effluent. The microtubes are formed into a bundle and epoxied at each end of the polycarbonate inner housing. Holes near each end of the inner housing provide for gas flow over the external surface of the microtubes. A quantity of 160 microtubes is adequate for the design conditions specified for the two test units. However, the saturator design can handle a practical maximum of about 600 microtubes leaving space for air flow.

2.2 DEGASSER

The Umpqua 70056-4 degasser construction is identical to that of the saturator (see Fig. 5 also) with the exception of the microtube material which is 0.040 cm I.D. x 0.046 O.D. Celgard microporous polypropylene (hydrophobic) with approximately 500 microtubes. Normally, only a small vacuum pump is used to remove the CO_2 and other gasses such as water vapor from the proximity of the microtubes to keep a high concentration gradient by drawing air through a gas port. By keeping the degasser temperature around 21 degrees C (i.e. room temperature), the water vapor passing through the membrane will be minimized. If the heat exchanger is operating properly, the temperature should be around 21 degrees C. At higher temperatures the rate of water vapor transport increases proportionally to the partial pressure of water.

2.3 CATALYTIC REACTOR

The Umpqua 70064 reactor is constructed of 316 seamless stainless steel tubing with a wall thickness of 0.065 inch to minimize the temperature gradient across the wall. The threaded end caps are sealed with viton O-rings (See Fig. 6). A temperature monitoring port is provided to access the center of the reactor with a 1/8 inch diameter probe. The catalyst is packed into the reactor and retained at either end with 40 or 100 micron stainless steel frits. There is a compression spring at one end to compact the catalyst and minimize catalyst fluidization. The spring is compressed 2 inches initially and exerts about 22 lbs force. The active volume of the reactor is about 155 cc's. The reactor is plumbed to provide plug flow of the influent so as to insure consistent contact time in the reactor. This configuration should also minimize channelling.

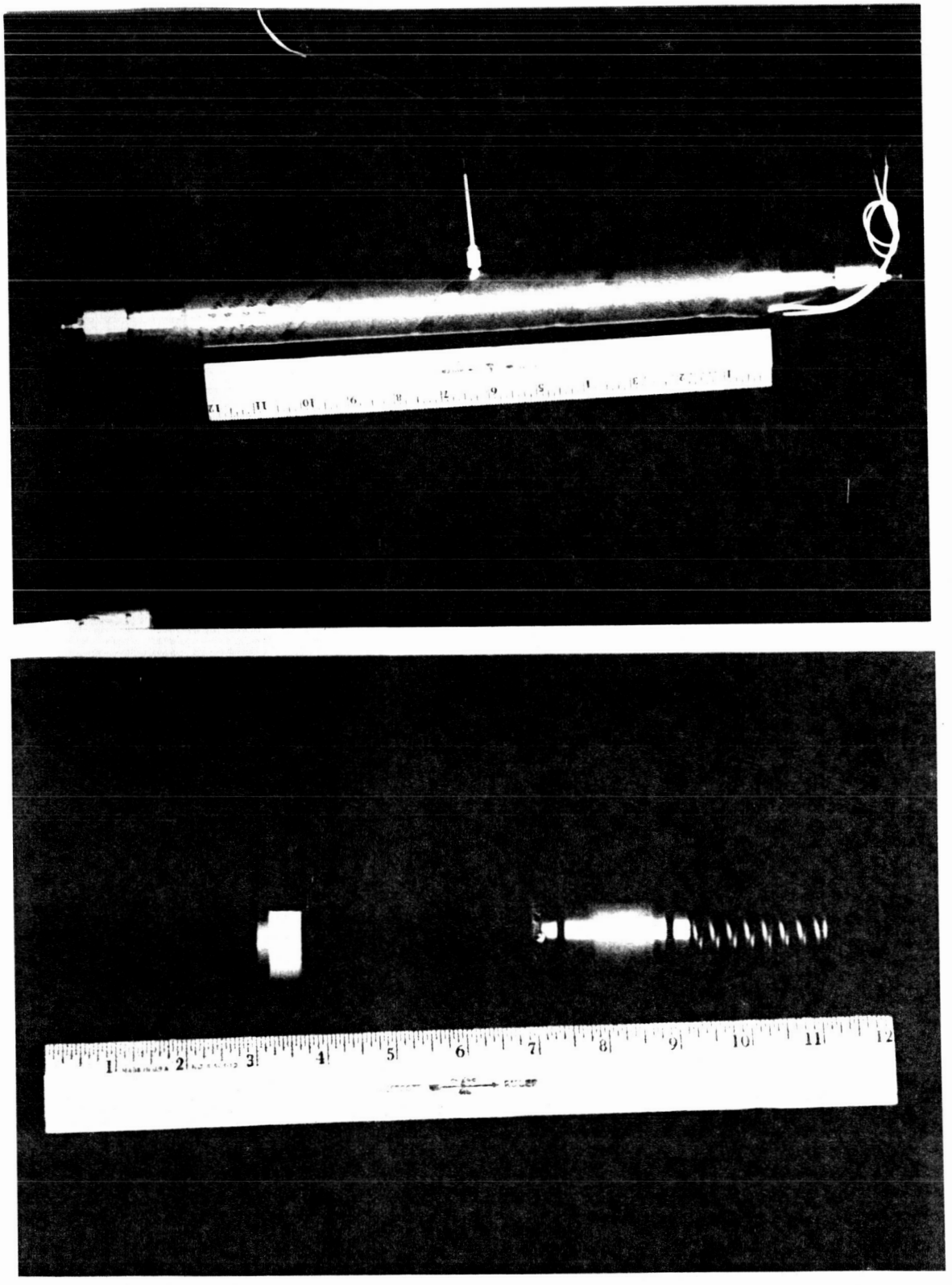


Figure 6 REACTOR
(Upper) Assembled View (Lower) Catalyst Retainers

A 400 watt foil heater is wrapped spirally around the outside of the reactor body securely with high temperature adhesive and held permanently in place with high temperature FEP shrink tubing having a maximum working temperature of 204 degrees C. A normally closed bi-metallic switch is located slightly above the RDT in contact with the shrink tubing limits the temperature to 138 degrees C. This heater design provides a uniform heat flux input to the reactor wall. The steady state temperature gradient from the wall to the center of the reactor is less than 1 degree C (with no voids). The steady state temperature of the heater strip is about 129 degrees C at a flow rate of 10 cc/min when the RDT is controlling at 121 degrees C.

The temperature at the center of the reactor can be controlled in the steady state condition to within 0.2 degrees C at a flow rate of 10 cc/min. This is quite good in view of the fact that the thermal system contains a large time delay because of the lag in the transfer of heat due to the transit time through the exchanger. The controller can only control the heat to the heater strip; it cannot control the heat entering the reactor from another source (i.e. exchanger). What happens is that the reactor and heat exchanger can "play catch" with some of the thermal energy which can result in large temperature oscillations in both the reactor and the exchanger depending on design values. In this particular case the thermal inertia of both the reactor and the heat exchanger are high compared with the amount of heat energy carried by the 10cc/min flow rate so that the temperatures of both can be stabilized with the proper single PID loop design.

The heat input to the exchanger is transferred to the effluent entering the reactor via the shell side of the heat exchanger and delayed by an amount,

$$T_d = V_h / R$$

where V_h is the shell side heat exchanger volume and R is the flow rate. For a shell side volume of 100 cc and a flow rate of 10 cc/min, T_d is 10 minutes which is a large time delay for which to compensate in a control system. In this case it is not a problem for low flow rates (e.g. 10 cc/min) where the reactor thermal inertia is high compared to the amount of heat entering the reactor. However, at high flow rates (e.g. 100 cc/min) the amount of heat energy entering the reactor from the heat exchanger is high compared with the thermal inertia of the system and oscillation will occur. Other techniques

would then be required to control temperature of the reactor. Control systems with time delays are not easily analyzed with linear control systems theory (e.g. complex plane analysis, Bode plots, etc.) More complex systems generally require computer modeling and simulation for analysis. Control of the temperature at high flow rates (above 50 cc/min) will probably require more sophisticated techniques such as cascade control.

A temperature gradient also exists along the longitudinal axis of the reactor stream. The effluent is heated rapidly from an input temperature of about 105 degrees C (depending on the efficiency of the heat exchanger due to entrapped gas) entering the reactor to a value of 121 degrees C by the time it reaches the central area of the reactor and continues to absorb heat until it passes out at a temperature of 129 degrees C which is the temperature of the heater. These values are for a flow rate of 10 cc/min. The exact entrance and exit temperatures will depend on flow rates and will decrease somewhat for higher flows. A more complex design would be required to hold the longitudinal temperature gradient in the reactor to tighter tolerances. The present design is considered adequate for the program.

2.4 HEAT EXCHANGER

A heat exchanger (Figure 7) is used in the system to conserve energy and to return the influent stream to ambient temperature before passing through the degasser. This also significantly reduces the amount of water vapor which passes out of the degasser. The exchanger is an Exergy Inc. (of Hanson, MA) model 23-406-2.4-316 stainless steel, and measures 1 inch diameter by 15.7 inches long. It is Ni/Cr vacuum brazed tube and shell construction with 37 tubes and 13 baffles. It provides a heat transfer area of 1.19 square ft. The end bonnets are sealed with viton O-rings. Operational temperature limits are determined by the O-ring seals.

The insulation surrounding the heat exchanger (and the reactor) is TechLite Melamine foam, a product of Accessible Products Company of Tempe AZ. It has a high temperature limit of 204 degrees C. The thermal conductivity is about that of glass wool at room temperature, but doubles in value at 125 degrees C.

The system is plumbed to provide plug flow through the tube section. This is very important to the overall efficiency of the exchanger because of the bubbles formed due to supersaturation of gasses in the liquid stream which tend to attach to metal surfaces in the exchanger

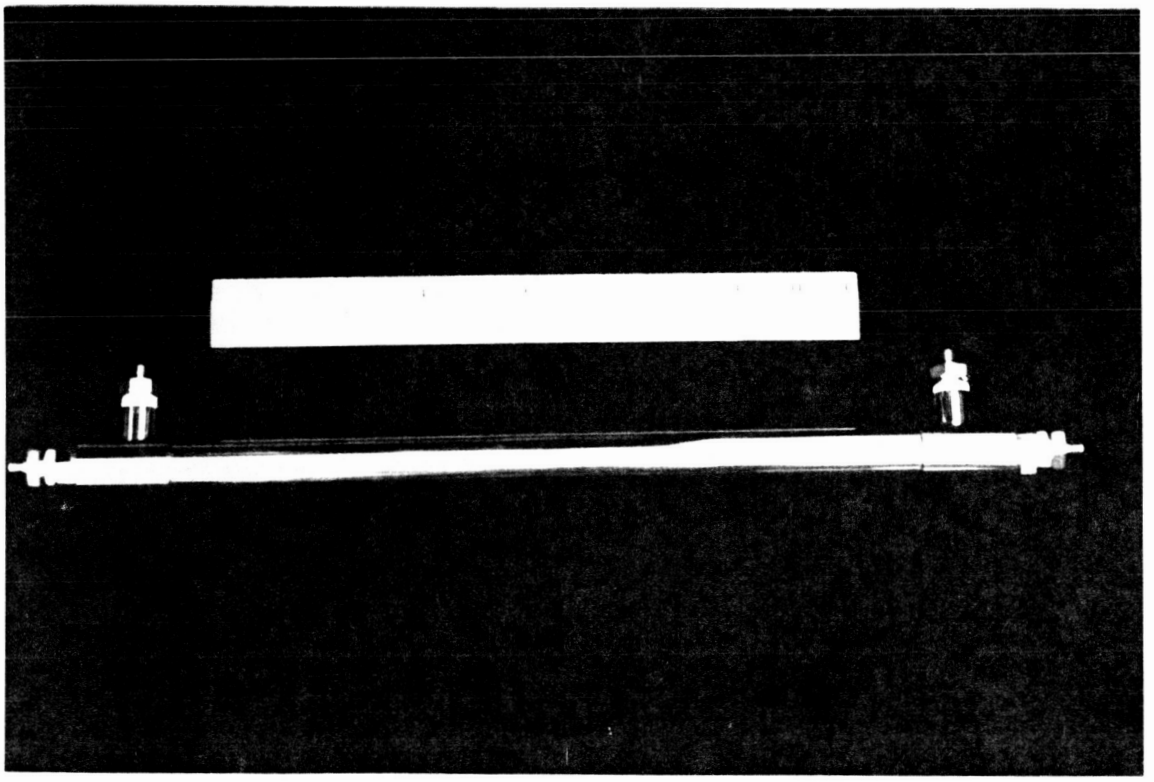


Figure 7. ENERGY HEAT EXCHANGER

and reduce the heat transfer film coefficient. This tends to aid buoyancy forces in sweeping bubbles in the stream through the exchanger and helping to prevent their build up in the tube side of the exchanger. After passing through the reactor, some of the dissolved oxygen is converted to CO_2 , and the stream is no longer supersaturated (this is pH dependent). So it is important to plumb the output of the saturator through the tube side of the heat exchanger. Unfortunately, the baffles are not designed to facilitate the passage of bubbles through the shell side.

2.5 VACUUM PUMP

A Whisper 500 aquarium air pump manufactured by Willinger Bros. Inc. of Oakland, N.J. was modified to serve as a vacuum pump. It is capable of providing a partial vacuum of about 5 inches of water maximum static head and is adjustable to about 2.5 inches of water. It can draw about 1.6 liters/min of air flow. This is sufficient to draw enough air through the degasser shell to preclude the buildup of diffusion gasses which would affect the concentration gradient across the membrane.

2.6 FRAME

The unit frames are constructed of anodized aluminum channel with 1/2 inch vertical aluminum rods to provide a means of supporting the components in a vertical orientation. Plastic electrical wire cable ties are used as a convenient and inexpensive means of securing the components to the vertical frame members. The components can be removed from the frame by simply cutting and discarding the plastic tie. The discarded tie is then replaced with a new one. An instrument panel is mounted to the upper right corner of the frame to support the vacuum gauge, switches, and temperature controller.

2.7 ELECTRICAL

The electrical schematic is shown in Fig. 8. 115 V A.C. power is provided to the Watlow temperature controller and also to the heating element in the reactor. A 25 amp solid state relay (SSR) provides a reliable means of switching power to the reactor heater. The SSR is switched on and off by the temperature controller based on the algorithm determined by the PID controller constants and the cycle time. The SSR is bolted to the bottom side of the frame above the controller. A (HEATER) switch is provided on the instrument panel to interrupt the low voltage control signal to the SSR preventing the SSR from turning on even though the controller is putting

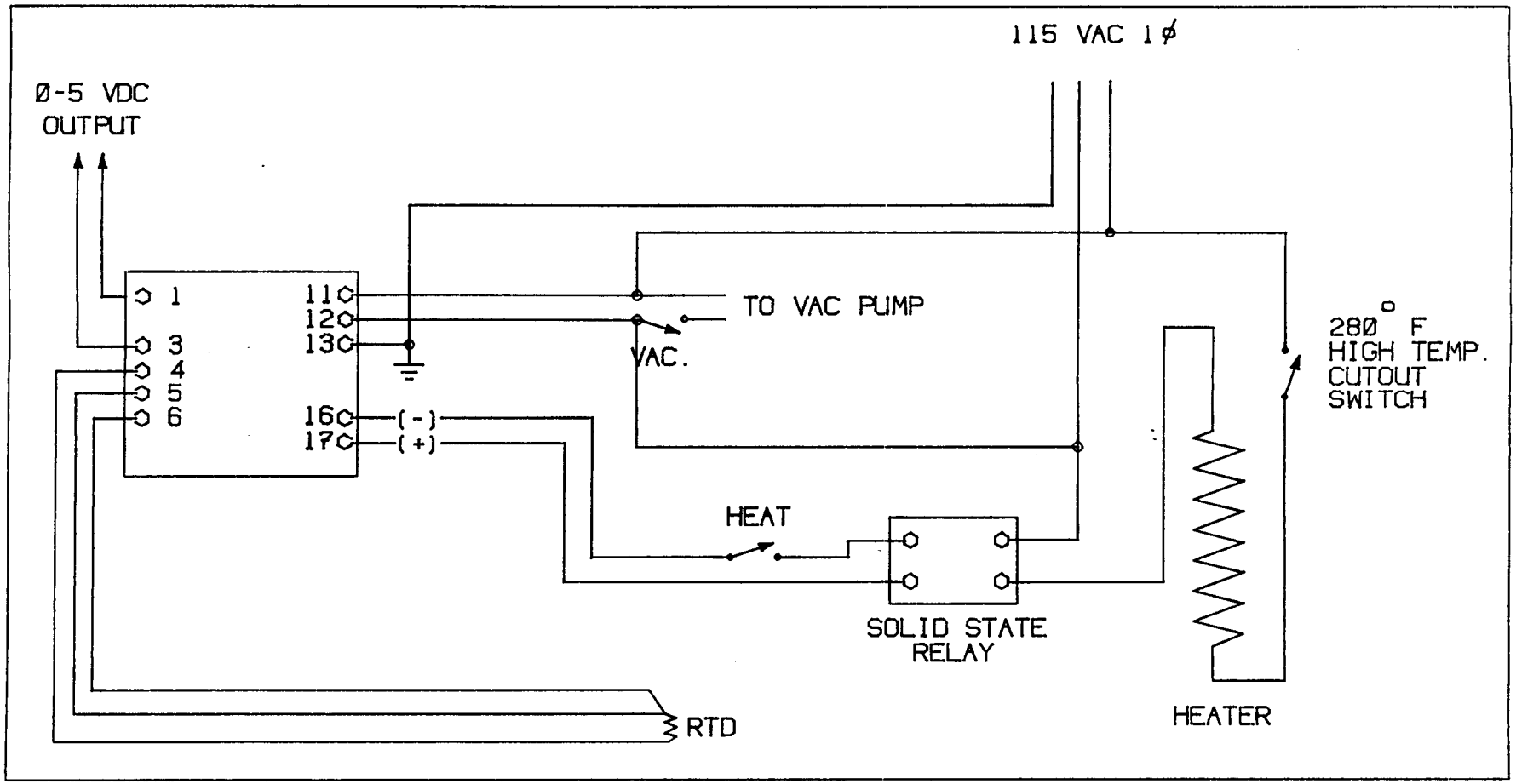


FIGURE 8

ELECTRICAL SCHEMATIC

out an ON signal. This makes it possible to turn off the reactor heater without changing any settings of the controller. A 280 degree F (138 C) normally closed bi-metal switch provides over-temperature protection. The RTD monitors temperature to an accuracy of 0.1 degree C. A (VAC) switch is provided on the instrument panel to turn on/off the vacuum pump. The controller also can provide a 0-5 v D.C. scaled output signal for continuous monitoring of reactor temperature.

2.8 SORBENT BEDS

The purpose of the sorption beds is first to remove iodine from the influent stream to protect the catalyst from degradation. In one of the configurations a second function is to remove sorbable organic and inorganic species from the influent which increases the oxidation efficiency. Thirdly, it is to remove constituents whose oxidized form is not gaseous such as SO_4^{--} or are products of incomplete breakdown such as the organic acids. The final function of the beds is to iodinate the processed potable water to protect it from microbiological contamination. The beds are mounted and plumbed to provide plug flow of the stream so that the contact time will be predictable. The beds are housed in stainless steel tubing with a teflon inner coating. The endcaps are also stainless steel sealed with viton O-rings. The design of each of the beds is covered in the technical documents accompanying this manual.

III. OPERATION

1. ANCILLARY EQUIPMENT

The additional items required for operation of the two test units are those associated with providing the influent stream to the inlet port at a pressure of 30 psig. These are,

a. Influent pump.
b. Influent pressure regulator.
c. Influent pressure gauge.
d. Influent pressure damper (if not continuous pressure pump.)
e. Influent reservoir.
f. Oxygen bottle and regulator.
g. 1/8th and 1/4th inch tubing and connectors.
h. Tygon tubing.
i. 5 gallons of startup fluid.

The only other requirement is a source of 115 v A.C. power.

2. STERILIZATION

The test units have been sterilized to prevent internal bacterial growth and this condition should be preserved during startup. Proper operation of the test units will keep the effluent sterile. The pretreatment bed on unit 2 has an iodinator, but unit 1 has no pretreatment bed because free iodine reacts with the condensate to change the TOC. Since the reactor and exchanger temperatures will take care of any organisms in solution (except perhaps special high temperature classes), the only concern is the sterility of the line between the heat exchanger outlet and the polishing bed. This line, which includes the degasser, may be sterilized with a few percent solution of a chlorine based bleach by disconnecting the line at the exchanger and the polishing bed. Chlorine based antibacterial agents should not be used on the catalyst and therefore should not be used in the influent stream. It may also be desirable to sterilize the pump and other ancillary equipment used with the influent before startup of the units in a similar manner.

3. STARTUP PROCEDURE

The following steps should be performed in sequence for startup:

a. Connect the ancillary equipment so as to provide an influent stream to the input port of the test unit and oxygen to the flow valve on the side port of the saturator. Connect Tygon or polyethylene tubing to the outlet side of the valve at the top of the Reactor. (This will allow monitoring the presence of gas in the Reactor.) Connect another plastic tube to the valve immediately downstream of the 2.0 micron filter.

b. Turn the Oxygen INLET valve to the OPEN position and adjust the Oxygen pressure to 30 psig. Insure that the effluent OUTLET valve is CLOSED. Open the influent INLET valve. Turn on the influent pump and adjust the influent pressure to 30 psig. Open the sample port valve downstream of the filter and adjust the flow rate through the needle valve to about 5 cc/min. Adjust the valve at the top of the Reactor so as to constrain the flow rate to about 5 to 10 cc/min and observe any bubbles moving through the plastic tubing. (This is an indication of gas trapped in the system.) Check for fluid leaks.

c. Move the HEATER switch to the OFF position and plug the temperature controller into an 120 v AC outlet. Insure that the controller constants are proper set (see section d below and Appendix I.) The small red LI light should come on indicating that the controller is trying

to apply power to the heater to raise the temperature. The upper controller window reads reactor temperature which should be near ambient.

d. Adjust the controller set point (lower window) to 80 degrees C by pressing the UP or DOWN ARROWs on the faceplate. (This will keep the reactor temperature below the boiling point until all trapped gas has been removed from the system.)

e. Move the HEATER switch to the ON position. The temperature displayed in the upper window should begin to rise almost immediately and should reach 80 degrees within about 5 minutes or less depending on flow rate.

f. The influent should be allowed to flow through the system bypassing the degasser and post beds until all gas is removed from the heat exchanger and reactor. Any entrapped gasses in the reactor can prevent the temperature sensor from accurately reading the stream temperature, and it also impedes the conduction of heat to the fluid stream. Continue to monitor the bubbles (gas) flowing out of the Reactor. (It may require several hours to completely rid the system of all entrapped gas if the system has been shut down long.) When the system appears to be gas free, go to the next step.

g. Move the valve at the top of the Reactor to the CLOSED position to retain pressure inside the Reactor. Adjust the temperature Set Point to 100 degrees C. When the temperature of the reactor approaches the 100 degree setpoint observe the temperature values in the upper window. The values should show a little temperature overshoot and then settle down to the control value within 1 degree. (Large overshoots are usually due to too little or no flow through the Reactor.) If the temperature begins to decrease before reaching the Set Point, then gas has impeded the sensing process and must be removed. You should return to paragraph f. above.

h. If the system is successfully controlling temperature at 100 degrees C, then increase the temperature Set Point to 105 degrees C and again observe how the temperature values in the upper window approach the Set Point. If the values increase and then decrease from some maximum before reaching the Set Point, then there is still free gas which must be removed. This is the critical test. Return to paragraph f if unsuccessful.

i. Once the system will hold 105 degrees C accurately, it is an indication that all the free gas has been removed from the system. Adjust the temperature Set Point to 121

degrees C. The Reactor temperature should reach the Set Point in a few minutes and then settle down to the Set Point value within 1 degree or better depending on flow rate and controller constants.

j. CLOSE the sample port valve downstream of the filter and OPEN the system effluent OUTLET valve. Adjust the OUTLET needle valve to obtained a flow rate of 10 cc/min. This is best done with a small graduate cylinder and a stop watch. Note: the flow rate through the needle valve may vary by 10 % or so over time.

k. Check for leaks and allow the system to settle down (reach steady state) chemically. This may require overnight operation in order to get valid readings. Always check the flow rate before sampling and adjust accordingly. The reactor temperature will keep the system sterile so long as it is running at a set point of 121.

4. TEMPERATURE CONTROL

The Watlow 945 temperature controller keeps the central reactor temperature within a fraction of a degree C if the PID constants are properly set. (Refer to Appendix I for detailed instructions for the controller.) The control parameters are set in by simply pressing the MODE switch and adjusting the values or selections in the upper window with the UP and DOWN arrows. The following PID control parameters are correct for 10 cc/min flow rate:

Pb = 5	(proportional gain)
rEl= 0.39	(integral rate)
rAl= 0.25	(derivative rate)
ctl= 2	(cycle time,sec.)

Some terms are not selectable, but CAL may be set to 0 and AUT (Auto tune) to 0 if not tuning. Make sure that the above control parameters are properly set into the controller before startup. The PID constants may change slightly for different conditions. To use the auto-tune feature of the controller, set AUT to 3 after reaching steady state conditions. It may be necessary to use auto-tune more than once to "home into" the best PID parameter values. A cycle time (ctl) of a few seconds allows close control and the SSR provides essentially unlimited relay life. Changes in the tuning parameters should only be necessary, if the flow rate deviates by more than 20% from 10 cc/min.

The Setup menu is reached by simultaneously pressing the UP and DOWN arrow keys for 3 seconds. The following is a list of values for the Setup parameters:

```
LOC - 0
In  - rtd
vsP - off
C-F - C
rL  = -73.3 *
rH  = 200.0 *
Otl - ht
Hysl= 0.2
RL2 - Pr
LAt2- nLR
Hys4= 0.2
rtd - din
```

* denotes values determined by sensor selection.

5. SHUTDOWN PROCEDURE

The test units should be shut down in such a way as to maintain sterility and prevent a change of phase in the reactor. The following sequential steps should be taken:

a. Turn the outlet valve to the OFF position. This will stop influent flow and maintain system pressure at 30 psig.

b. Move the HEATER switch to the OFF position and monitor the decrease in reactor temperature.

c. When the reactor temperature drops below 80 degrees C, turn off the influent pump and turn the unit INLET valve to the OFF position. Turn the oxygen inlet valve to the OFF position also.

d. Continue to monitor the reactor temperature to insure that it is decreasing. When the temperature reaches 60 degrees C, you may remove the electrical power. The system is now shutdown and may be stored. To reactivate following the procedure in paragraph 3 above.

6. OPERATIONAL PROBLEM ANALYSIS

The following is a partial list of problem symptoms and possible causes.

a. Influent flow

Inlet or outlet valve closed
Needle valve needs adjustment

Blocked filter
Empty influent reservoir
Low pump pressure
Gas pockets in reactor

b. Temperature out-of-limit

Incorrect or no flow rate
Incorrect PID constants
Gas pockets in reactor
Low system pressure
Malfunctioning temperature sensor

c. High TOC

Too high a flow rate
Reactor temperature too low
Insufficient oxygen or saturator not functioning properly
Catalyst poisoned
Depletion of post treatment bed.
Change in flow displacing catalytic adsorbed organic species. (Stable readings require at least 12 hours after large changes in challenge solution)

d. High TIC

Degasser not functioning properly
Pretreatment bed depleted
Too high pH
Vacuum pump not functioning properly

IV. DESIGN REQUIREMENTS FOR SPACE ENVIRONMENT

The test units are not designed for a space environment. No consideration has been given to weight, power, or micro gravity. In addition, a flight test model would have to be properly scaled to handle a given effluent flow rate which may have an effect on design parameters. The unibeds, saturator, and degasser designs can be easily adapted to space conditions. However, the questions involving channelling in the Reactor and unibeds remain unanswered. If the reactor does not employ electrical heating, then thermal design changes will be required.

The design of the heat exchanger is of particular importance for micro gravity where buoyancy forces are no longer present. Once the fluid stream passes through the saturator and is heated, it must be considered to be supersaturated with gasses (primarily O_2, CO_2, and diluent gasser). Buoyancy forces can no longer be utilized to help sweep the bubbles through the system or insure plug flow. The bubbles tend to attached

themselves to surfaces and inhibit heat transfer. Spring loading the catalyst should help to limit channeling and fluidization as the catalyst is depleted. A tube and shell type heat exchanger will not work efficiently in this kind of environment. A design that allows the bubbles to be swept through the system will work best. Adequate cooling of the effluent prior to the degasser is important to prevent the loss of too much water vapor.

APPENDIX I

WATLOW 945 TEMPERATURE CONTROLLER

USER'S MANUAL

2/92

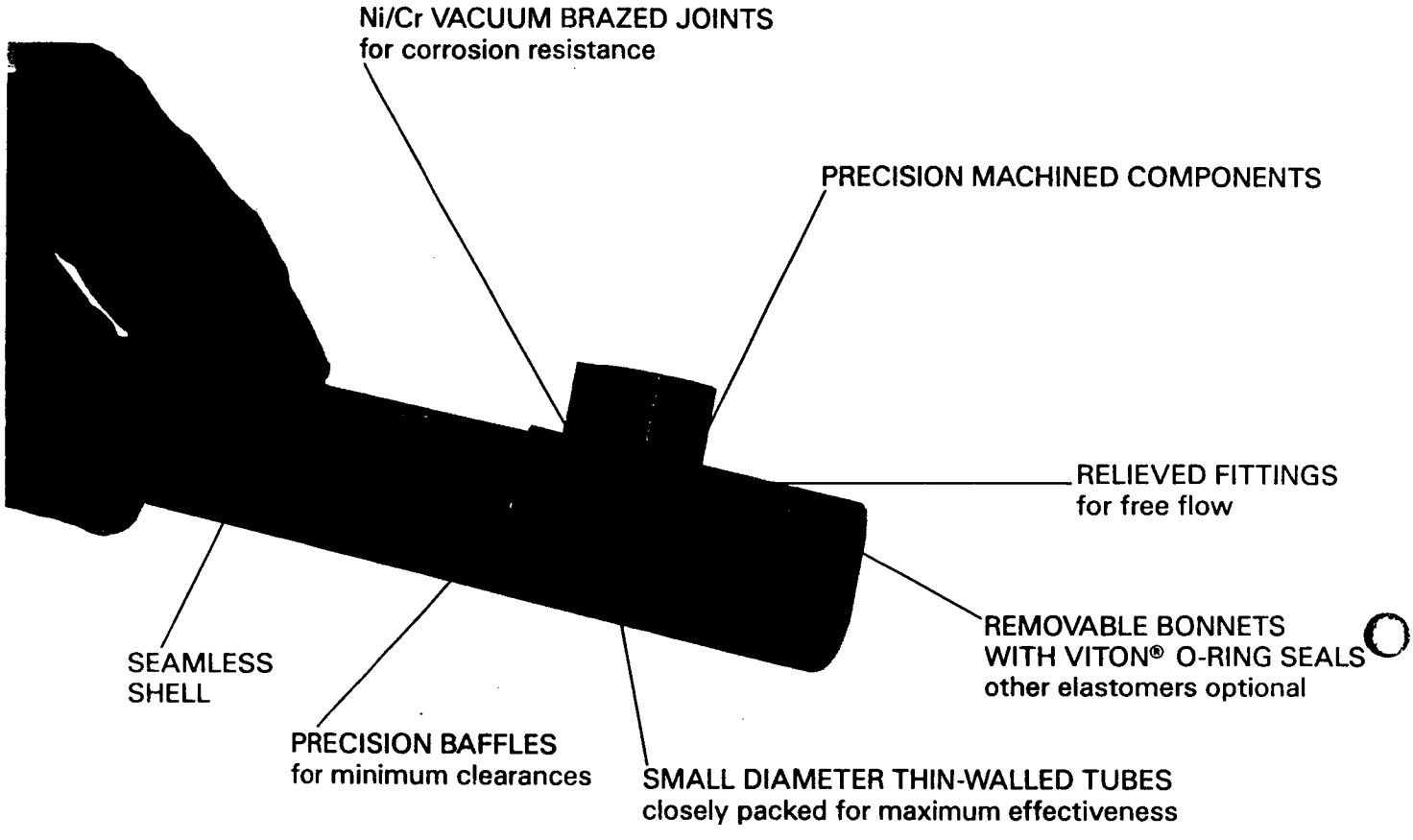
MINIATURE HEAT EXCHANGERS

Stainless Steel · Shell and Tube

EXERGY

EXERGY INCORPORATED

Miniature Shell & Tube Heat Exchangers



DESIGN FEATURES

- 316 low carbon stainless steel construction for **optimum corrosion resistance.**
- Compact geometry for **maximum thermal effectiveness.**
- Design pressures of **1000 to 1200 psig.** Custom designs can reach higher pressures.
- Removable bonnets with O-ring seals for easy tube side cleaning. **Custom fittings are also available.**

OPERATING LIMITATIONS

TEMPERATURE RANGE WITH VITON® SEALS:

She'l Side	−70 °F to 455 °F	(−60 °C to 235 °C)
Tube Side	−15 °F to 400 °F	(−25 °C to 205 °C)

OVERALL TEMPERATURE RANGE WITH OPTIONAL SEALS:

Shell Side	−125 °F to 555 °F	(−90 °C to 290 °C)
Tube Side	−70 °F to 500 °F	(−60 °C to 260 °C)

MAXIMUM MEAN TEMPERATURE DIFFERENCE FROM SHELL SIDE FLUID TO TUBE SIDE FLUID:
Consult factory if your application exceeds this limit. 150 °F (85 °C)

SHELL SIDE AND TUBE SIDE DESIGN PRESSURE:

23 mm Diameter	1200 PSI (8300 kPa)
35 mm Diameter	1000 PSI (6900 kPa)

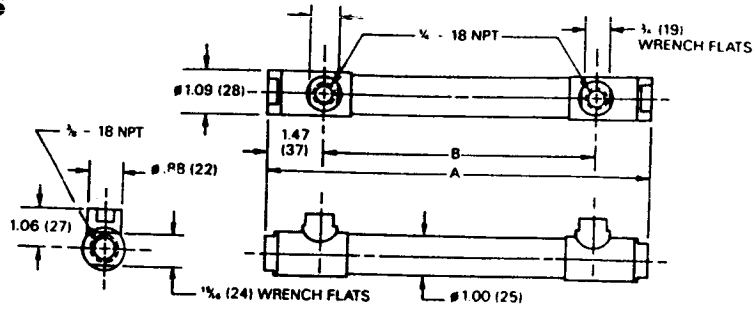
HYDROSTATIC TEST PRESSURE
3000 PSI (20 800 kPa)

Maximum allowable steam pressure is 125 psig.
Pressure ratings are maximum for non-shock service.

Product Information

23 mm DIAMETER HEAT EXCHANGERS

Dimensions in: inches (millimeters)

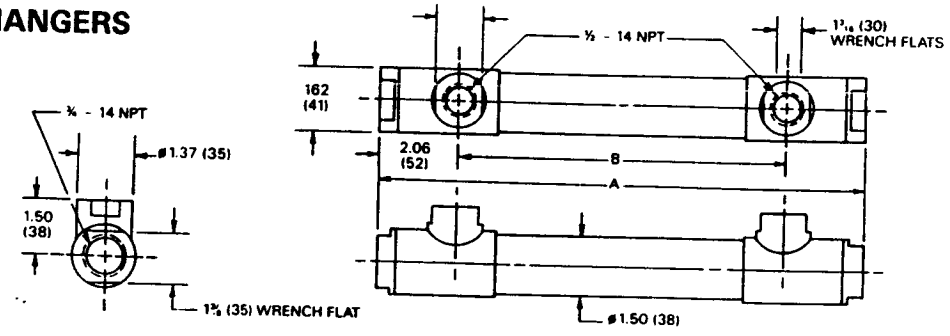


MODEL NUMBER*	TRANSFER AREA ft²	(m²)	TUBE LENGTH in	(mm)	"A" in	(mm)	"B" in	(mm)	BAFFLE COUNT	WEIGHT lbs	(kg)	SHELL VOLUME in³	(cc)	TUBE VOLUME in³	(cc)
23-203-2.4-316	0.58	0.055	7.70	(196)	9.75	(248)	6.81	(175)	9	0.9	(0.40)	3.1	(51)	1.8	(30)
23-305-2.4-316	0.88	0.083	11.70	(297)	13.75	(349)	10.81	(276)	11	1.2	(0.50)	4.6	(75)	2.5	(41)
23-406-2.4-316	1.19	0.111	15.70	(399)	17.75	(451)	14.81	(378)	13	1.5	(0.60)	6.2	(102)	3.2	(52)

All 23 mm sizes have 37 tubes of .094 in. (2.4 mm) OD by .0075 in. (0.19 mm) wall. Bonnet seals are 3-910 size O-rings. (82) (50)

35 mm DIAMETER HEAT EXCHANGERS

Dimensions in: inches (millimeters)

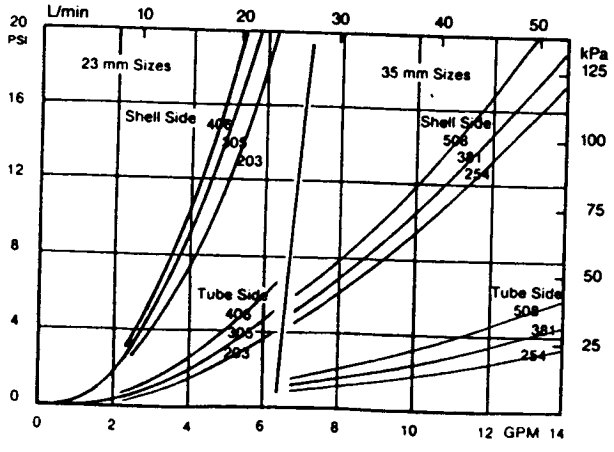


MODEL NUMBER*	TRANSFER AREA ft²	(m²)	TUBE LENGTH in	(mm)	"A" in	(mm)	"B" in	(mm)	BAFFLE COUNT	WEIGHT lbs	(kg)	SHELL VOLUME in³	(cc)	TUBE VOLUME in³	(cc)
35-254-3.2-316	1.43	0.133	9.54	(242)	12.28	(312)	8.16	(207)	7	2.7	(1.2)	8.3	(136)	5.8	(95)
35-381-3.2-316	2.18	0.203	14.54	(269)	17.28	(439)	13.16	(334)	9	3.4	(1.5)	12.3	(200)	8.1	(133)
35-508-3.2-316	2.93	0.272	19.54	(496)	22.28	(566)	18.16	(461)	11	4.1	(1.9)	16.2	(265)	10.5	(172)

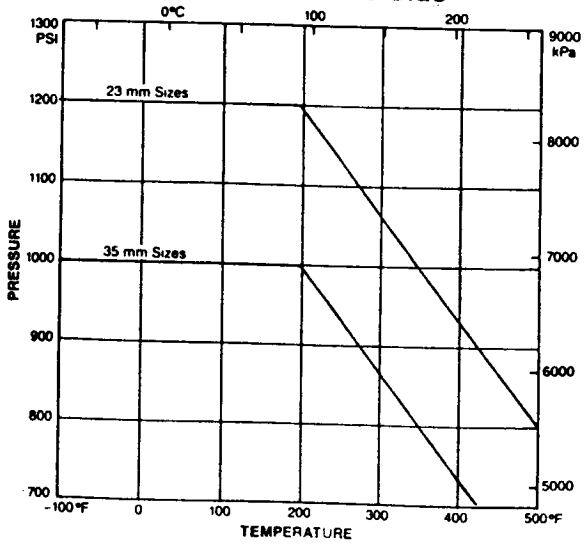
All 35 mm sizes have 55 tubes of .125 in. (3.2 mm) OD by .010 in. (.25 mm) wall. Bonnet seals are 2-217 size O-rings.

*Model numbers are the dimensions in millimeters of:
Shell ID — Tube Length — Tube OD — Material

Typical Pressure Loss for Water



Maximum Pressure vs. Temperature Shell Side or Tube Side



Ordering Information

When ordering please include the Model Numbers shown on the previous page.

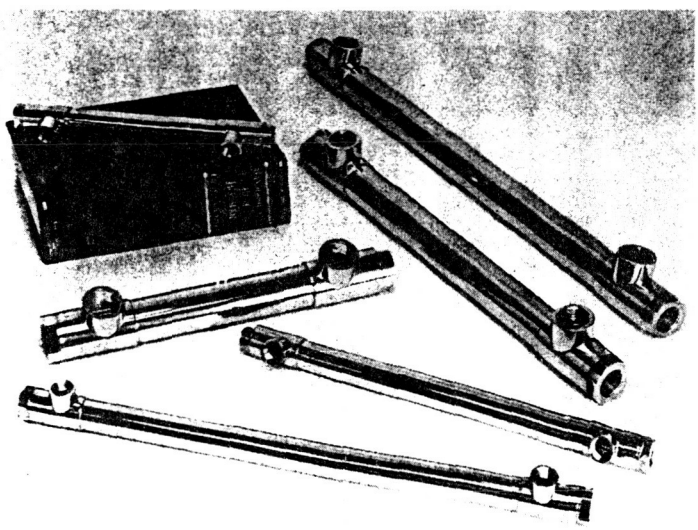
- **Bonnet Seals:** We have the following seals in stock:
  - Fluoroelastomer (Viton®) standard
  - Perfluoroelastomer (Kalrez®) (extra cost)
  - Nitrile (Buna N)
  - Ethylene Propylene Rubber

  Please specify which material you require.
- **Mounting Brackets:** Optional stainless steel mounting brackets are available.
- **Connections:** Seal nuts are available for the NPT connections. Non-standard bonnet and shell side fittings can be provided for otherwise standard heat exchangers.
- **Custom Design:** Exergy can design and build custom components and systems tailored to your specific needs and operating environment.
- **Application Assistance:** Please call us for application assistance. We will help you select the heat exchanger best suited to your needs. An application data sheet is included below to help you gather data.

Application Data Sheet

	FLUID 1	FLUID 2		FLUID 1	FLUID 2
Fluid Type			Allowable ΔP		
Heat Transferred			Phase Change?		
Flow Rate			Density		
Temperature In			Viscosity		
Temperature Out			Thermal Conductivity		
Pressure In			Specific Heat		

12/91



EXERGY

EXERGY INCORPORATED

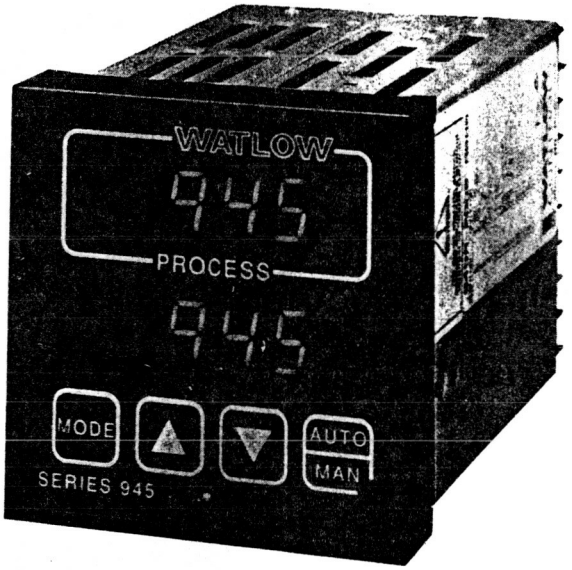
P.O. Box 209 · Hanson, Massachusetts 02341

Tel: (617) 294-8838 · Fax: 617-294-8144

APPENDIX II

EXERGY HEAT EXCHANGER DATA

Series 945



1/4 DIN Microprocessor-Based Auto-tuning Control

User's Manual

WATLOW

Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, Phone: 507/454-5300, Fax: 507/452-4507

W945-MA30-9119
May, 1991
Supersedes:
W945-MA20-9010

$10.00
Made in the U.S.A.
Printed on Recycled Paper

Contents

Notes

Informational notes alert you to important details. When you see a note icon, look for an explanation in the margin.

♪ or ♫

Safety Information

Boldface safety information protects both you and your equipment. Please be attentive to them. Here are explanations:

The WARNING symbol in the wide text column alerts you to a **"WARNING,"** a safety hazard which could affect you and the equipment. A full explanation is in the narrow column on the outside of the page.

The CAUTION symbol in the wide text column alerts you to a **"CAUTION,"** a safety or functional hazard which could affect your equipment or its performance. A full explanation is in the narrow column on the outside of the page.

Technical Assistance

If you encounter a problem with your Watlow Control, review all of your configuration information to verify that your selections are consistent with your application... Inputs, Outputs, Alarms, Limits, etc. If the problem persists after checking the above, you can get technical assistance by dialing: 1-507-454-5300

An Application Engineer will discuss your problem with you. Please have the following information available:

- Complete model number
- Serial Number
- All configuration information
- User's Manual

The model and serial numbers can be found on the outside of the case.

Your Feedback

Your comments or suggestions on this manual are welcome, please send them to: Technical Writer, Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, or phone 507/454-5300. The Watlow Series 945 User's Manual and integral software are copyrighted by Watlow Winona, Inc.,
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The Watlow Series 945, A Microprocessor-Based Control

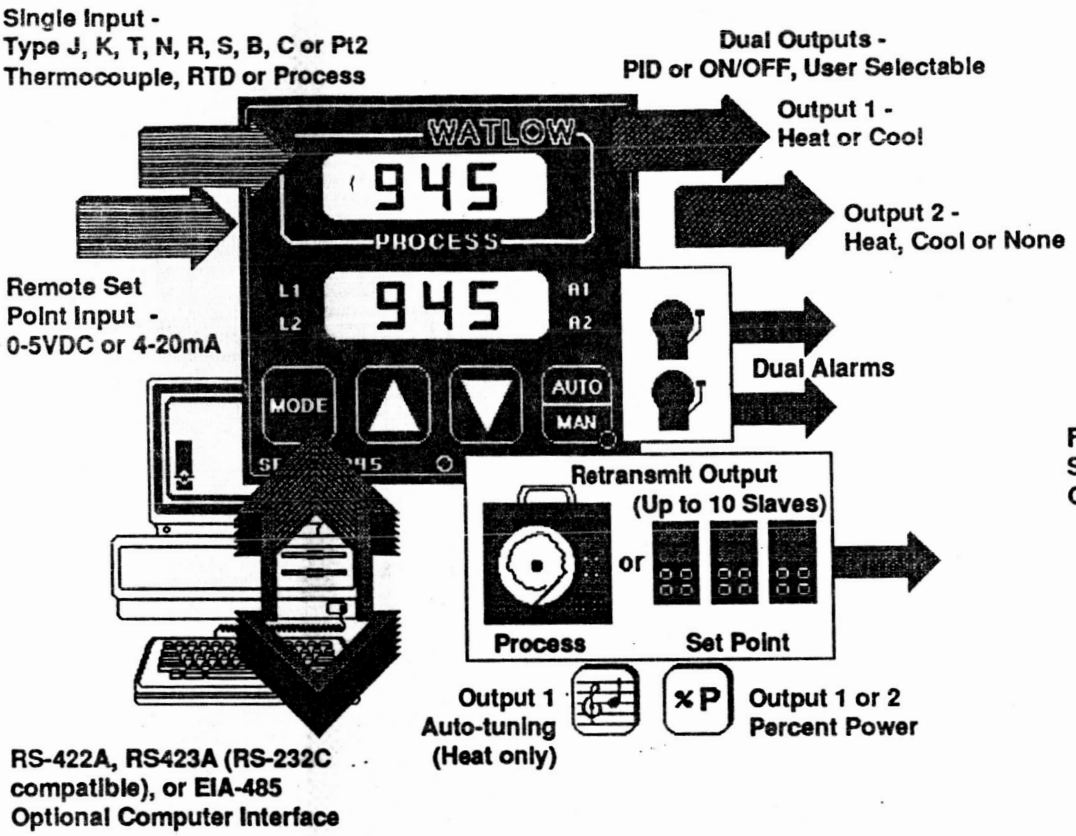


Figure 1 - Series 945 Input and Output Overview

General Description

Welcome to the Watlow Series 945, a 1/4 DIN microprocessor-based temperature control. It has a single input, remote set point input, dual output, and dual alarm. The 945 is an auto-tuning control when Output 1 is in the heat mode, and features Automatic/Manual capability with bumpless transfer. In the Auto mode, the 945 has closed loop control with sensory feedback, while the Manual mode has open loop control with user defined output power level. The 945 accepts a variety of thermocouples, as shown above, along with RTD, or process input. The primary output is heat or cool, while the secondary output can be heat, cool or none. An optional retransmit output is offered in place of one of the alarms. Selectable as retransmit of set point or process variable. Units with communications feature data logging with user selectable table, chart or SPC (Statistical Process Control) printout of data.

With the Series 945 you can select either PID or ON/OFF for Output 1 or 2. Input a complete set of PID parameters for both outputs, including proportional band, reset/integral and rate/derivative. By setting either output's proportional band to zero, the Series 945 becomes a simple ON/OFF control with the switching differential selectable under the HYS (hysteresis) parameter in the Setup menu.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 945 automatically stores all information in a non-volatile memory.

How to Install and Wire the Series 945

1. Make a panel cutout per the dimensions given below. Your panel thickness can be from 0.06" to 0.25" (1.52 to 6.35 mm).

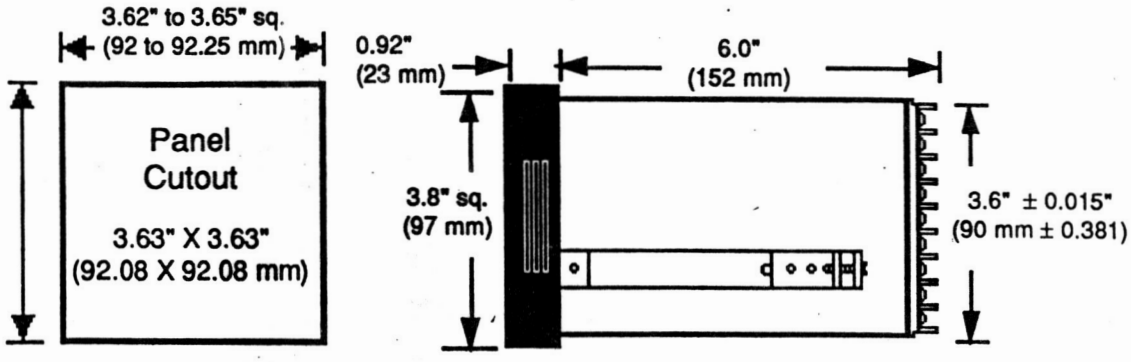


Figure 2 - Series 945 Panel Cutout and Unit Dimensions

2. Remove the 945 from its case by turning the front panel screw 90° counterclockwise (CCW). Grip the bezel firmly and pull the control out of the case.

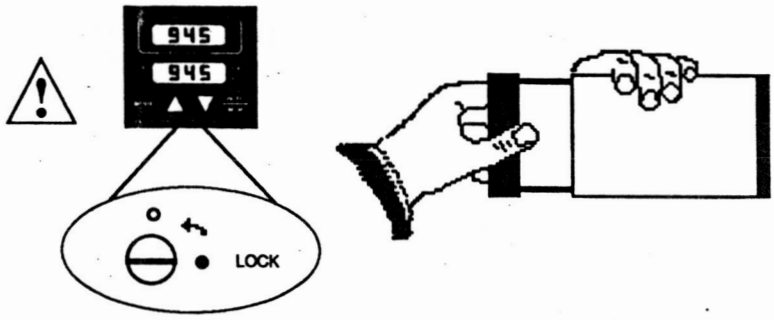


Figure 3 - How to Open the Series 945.

CAUTION:
The front panel screw turns 90° only. Do not apply excessive force or turn the screw more than 90°.

3. Place the case in the cutout you just made. Attach the two mounting brackets, shipped with your unit, either to the top and bottom, or to both sides of the unit. Tighten the brackets securely against your panel.

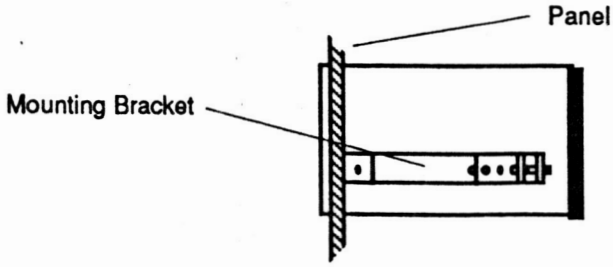


Figure 4 - Mounting the Series 945 Case.

4. Insert the control chassis into its case and press the bezel to seat it. Turn the front panel screw 90° clockwise (CW) to lock the control in place.

How to Wire the Series 945

The Series 945 wiring is illustrated by model number option. **Check the terminal designation sticker** on the control and compare your model number to those shown here and also the model number breakdown on the inside back cover of this manual.

Series 945 internal circuits appear "inside" the line drawing of the 945, while connections and terminal designations appear "outside" the line drawing. All outputs are referenced to a de-energized state. The final wiring figure is a typical system example.

When you apply power without a sensor input on the terminal strip, the Series 945 displays "- - - -" in the upper display, and "0" in the lower display. Press AUTO/MAN twice, and ER 7 is displayed for one second. This error indicates an open sensor or A/D error. Remove power to the control and connect the sensor properly, see Page 6. All wiring and fusing must conform to the National Electric Code and to any locally applicable codes as well.

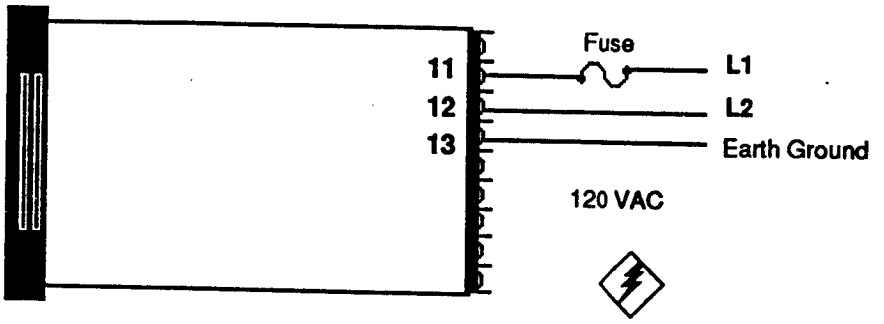


Figure 5 - 120 VAC Power Wiring

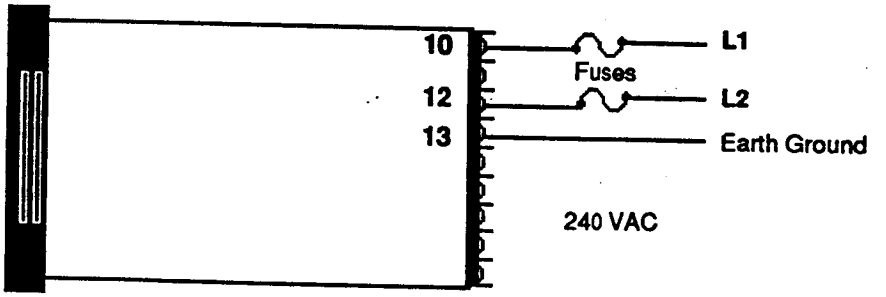


Figure 6 - 240 VAC Power Wiring

Sensor Installation Guidelines

We suggest you mount the sensor at a location in your process or system where it reads an average temperature. Choose a point that will adequately represent the process temperature without being overly reactive.

For thermocouple inputs: Use an isolated or ungrounded thermocouple if an external 4-20mA output device with a non-isolated circuit common is connected. Extension wire must be of the same alloy as the thermocouple itself to limit errors.

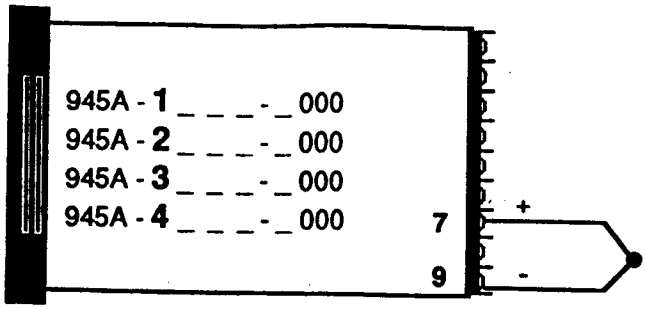
For RTD inputs: There could be a + 2°F input error for every 1Ω of lead length resistance when using a 2 wire RTD. That resistance, when added to the RTD element resistance, will result in erroneous input to the instrument. To overcome this problem, use a three wire RTD sensor, which compensates for lead length resistance. When extension wire is used for a three wire RTD, all wires must have the same electrical resistance (i.e. same gauge, copper stranded).

For 0-5VDC or 4-20mA process inputs: The rL and rH settings scale the display to match the measured range of the process signal. For 0-5VDC process input, the impedance is 100KΩ. For 4-20mA process input, the impedance is 249Ω.

WARNING:
To avoid potential electric shock, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices.

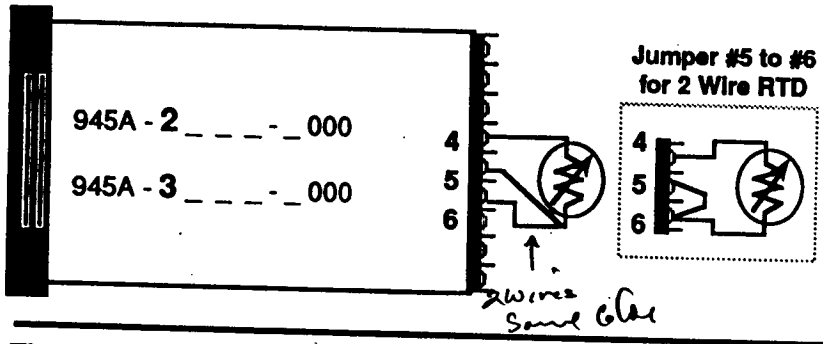
Thermocouple Input

Figure 7 - Thermocouple Input Wiring.



RTD, 2 or 3 Wire

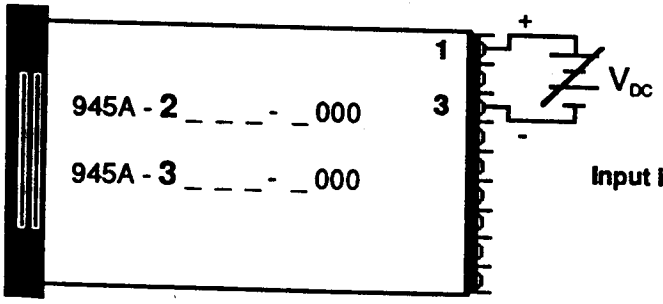
Figure 8 - 2 or 3 wire RTD Input Wiring.



These input connections are also used in conjunction with T/C and RTD sensor types when using the remote set point input.

0 - 5VDC Process or Remote Set Point Input

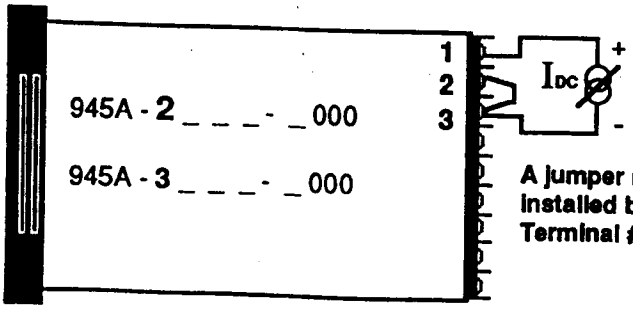
Figure 9 - 0 - 5 VDC Process Input Wiring.



Input impedance: 100KΩ

4 - 20mA Process or Remote Set Point Input

Figure 10 - 4-20mA Process Input Wiring.



4-20mA process input: 249Ω.

A jumper must be installed between Terminal #2 and 3.

Output 1 - Solid State Relay With Contact Suppression

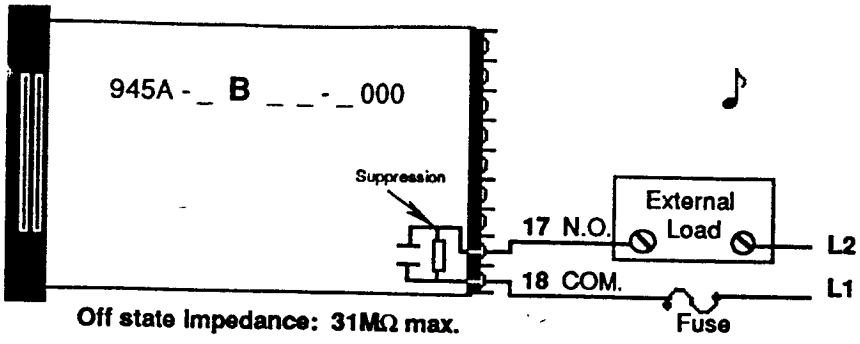


Figure 11 - Solid State Relay With Contact Suppression

Output 1 - Switched DC Output (Open Collector)

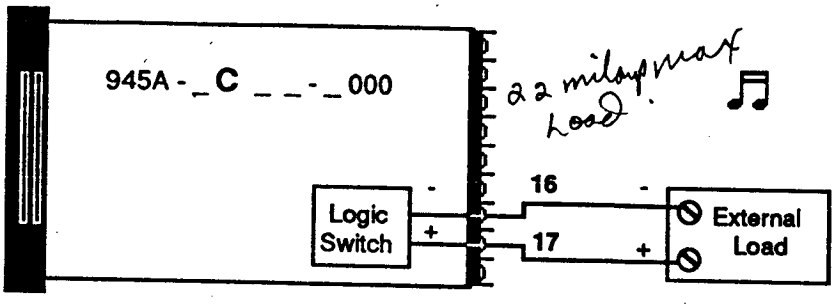


Figure 12 - Switched DC (Open Collector)

NOTE:
Minimum load resistance is 500Ω. Available current is 22mA maximum. Typical voltage drop across a 1KΩ load is 12 to 19 volts.

Output 1 - Mechanical Relay, 6 Amp, Form C

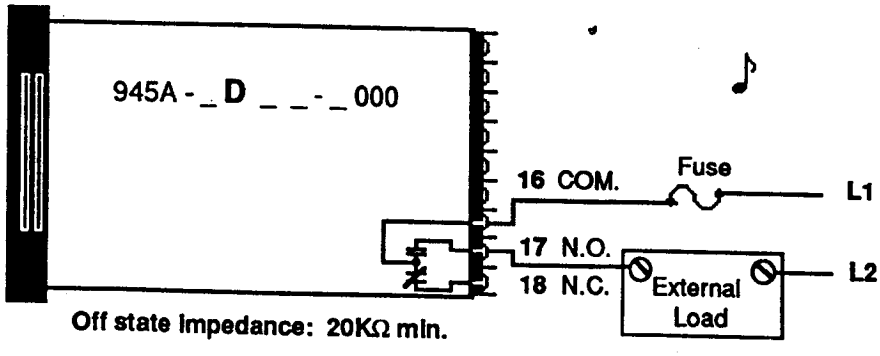


Figure 13 - 6 Amp Mechanical Relay

NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Output 1 - Process, 4 - 20mA

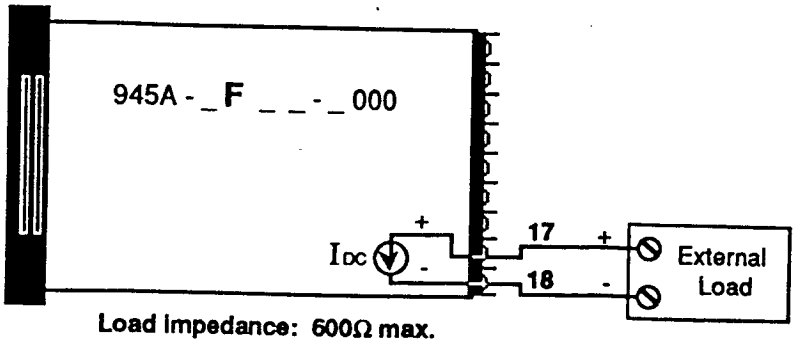
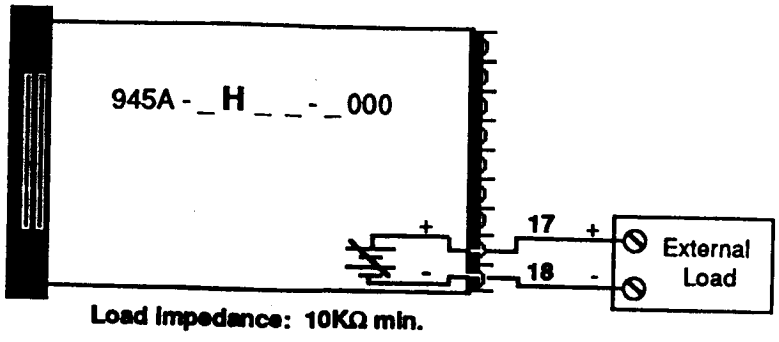


Figure 14 - Process, 4-20mA

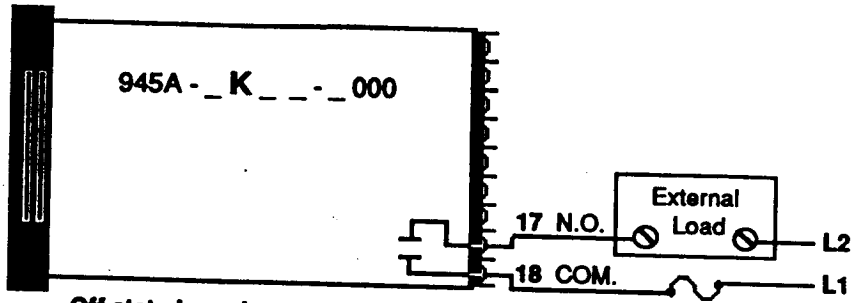
Output 1 - Process, 0 - 5VDC



Load impedance: 10KΩ min.

Figure 15 - Process, 0 - 5VDC

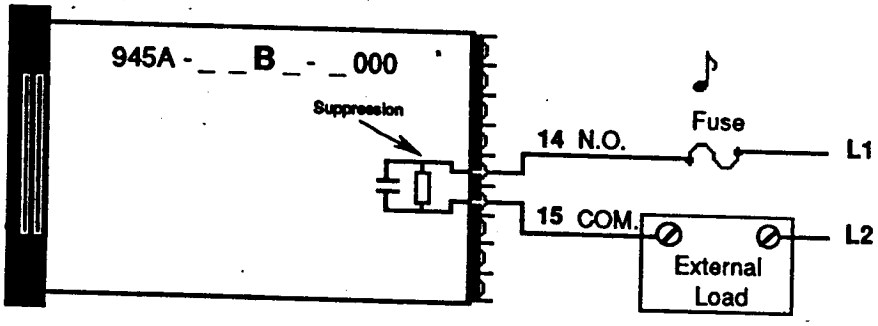
Output 1 - Solid State Relay Without Contact Suppression



Off state impedance: 31MΩ max.

Figure 16 - Solid State Relay Without Contact Suppression

Output 2 - Solid State Relay With Contact Suppression



Off state impedance: 31MΩ max.

Figure 17 - Solid State Relay With Contact Suppression

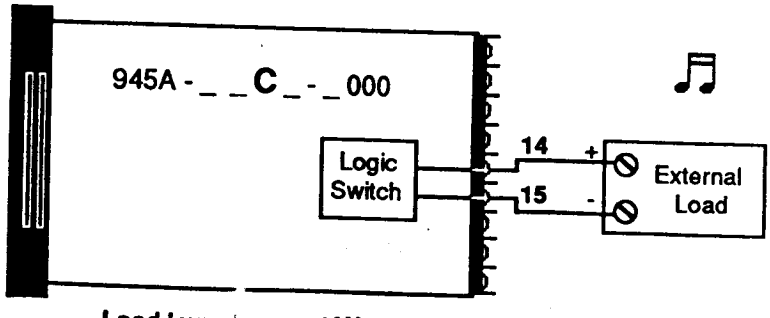
NOTE:

This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

NOTE:

Minimum load resistance is 500Ω. Available current is 22mA maximum. Typical voltage drop across a 1KΩ load is 12 to 19 volts.

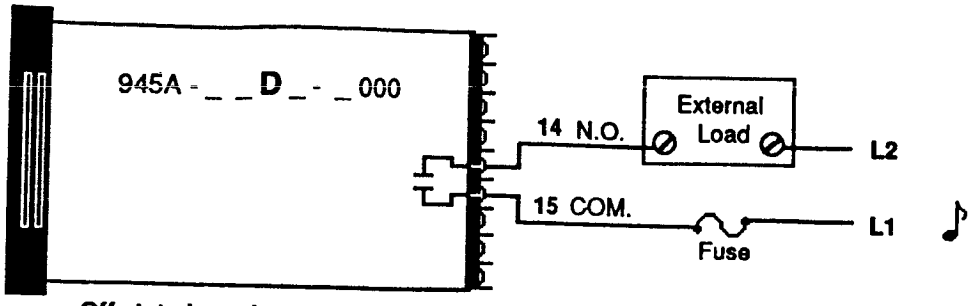
Output 2 - Switched DC Output (Open Collector)



Load impedance: 10KΩ min.

Figure 18 - Switched DC Output (Open Collector)

Output 2 - Mechanical Relay, 6 Amp, Form A

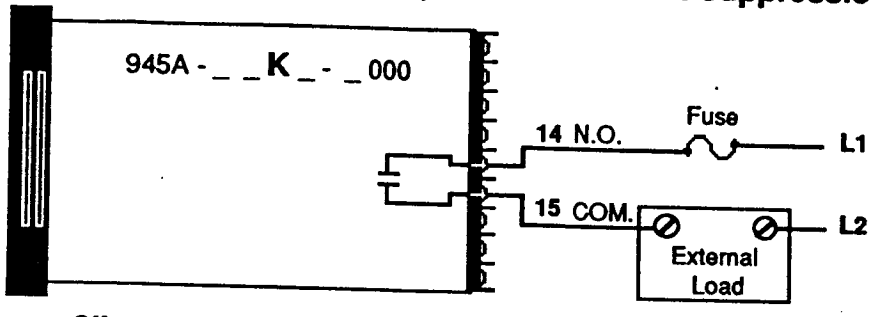


Off state impedance: 20KΩ min.

Figure 19 - 6 Amp Mechanical Relay

♪ NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Output 2 - Solid State Relay Without Contact Suppression

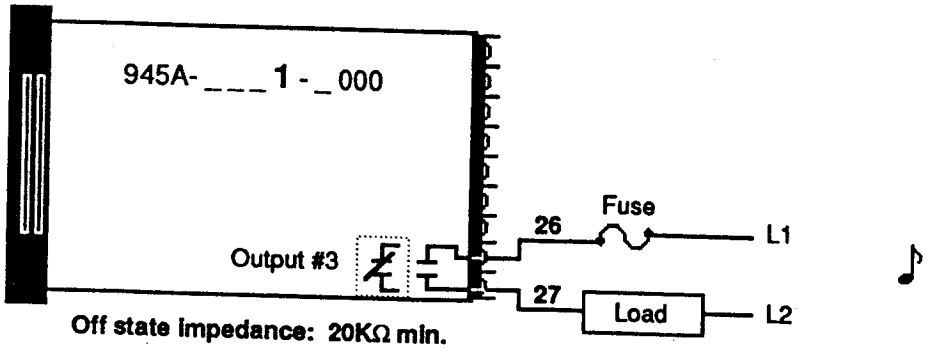


Off state impedance: 31MΩ max.

Figure 20 - Solid State Relay Without Contact Suppression

For more information on alarms and alarm jumper selection, see Chapter 5.

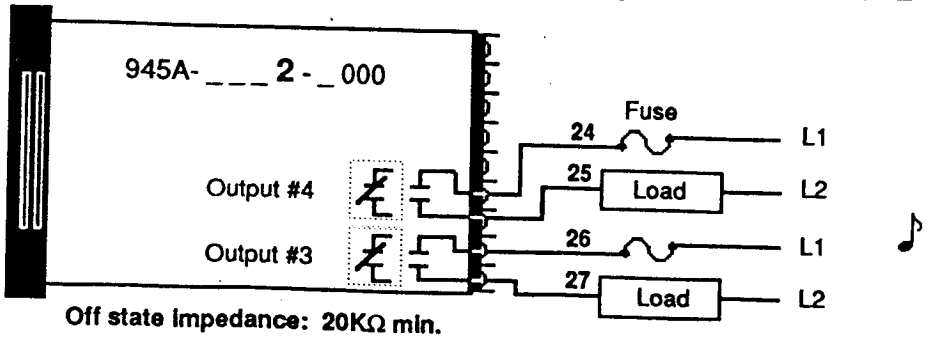
Alarm Output - Mechanical Relay, 6 Amp, Single Form A or B



Off state impedance: 20KΩ min.

Figure 21 - Alarms Option 1 Wiring.

Alarm Output - Mechanical Relay, 6 Amp, Dual Form A or B

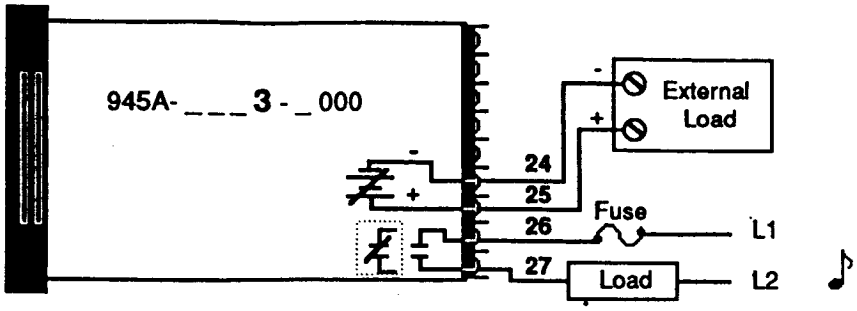


Off state impedance: 20KΩ min.

Figure 22 - Alarms Option 2 Wiring.

Mechanical Relay, 6 Amp, Form A or B/0 - 5VDC Retransmit

Figure 23 - Alarm/Retransmit Option 3 Wiring.

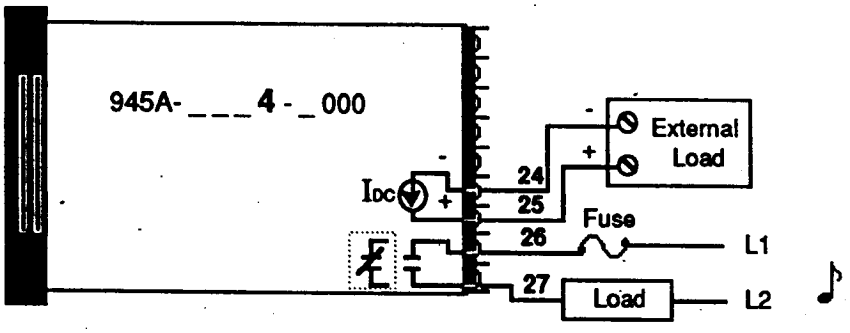


♪ NOTE:
This output is supplied with an arc suppression snubber across the output terminals. High impedance loads may remain energized even though the output device is turned OFF.

Load impedance: 10KΩ min. for 0-5VDC. Relay offstate impedance: 20KΩ.

Mechanical Relay, 6 Amp, Form A or B/4 - 20mA Retransmit

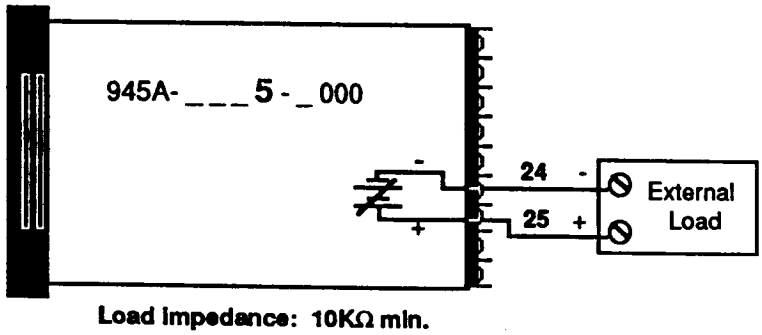
Figure 24 - Alarm/Retransmit Option 4 Wiring.



Load impedance: 10KΩ min. for 4-20mA. Relay offstate impedance: 20KΩ.

0 - 5VDC Retransmit Output

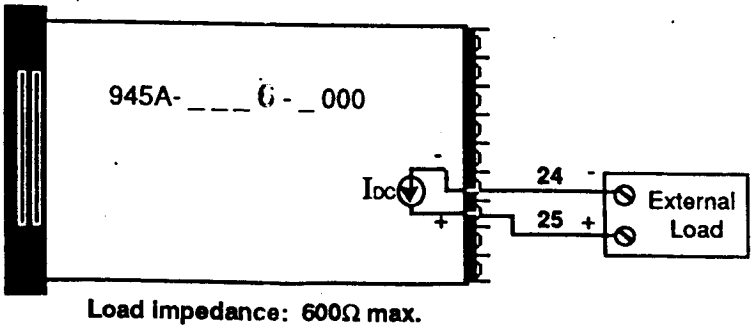
Figure 25 - Retransmit Option 5 Wiring.



Load impedance: 10KΩ min.

4 - 20mA Retransmit Output

Figure 26 - Retransmit Option 6 Wiring.



Load impedance: 600Ω max.

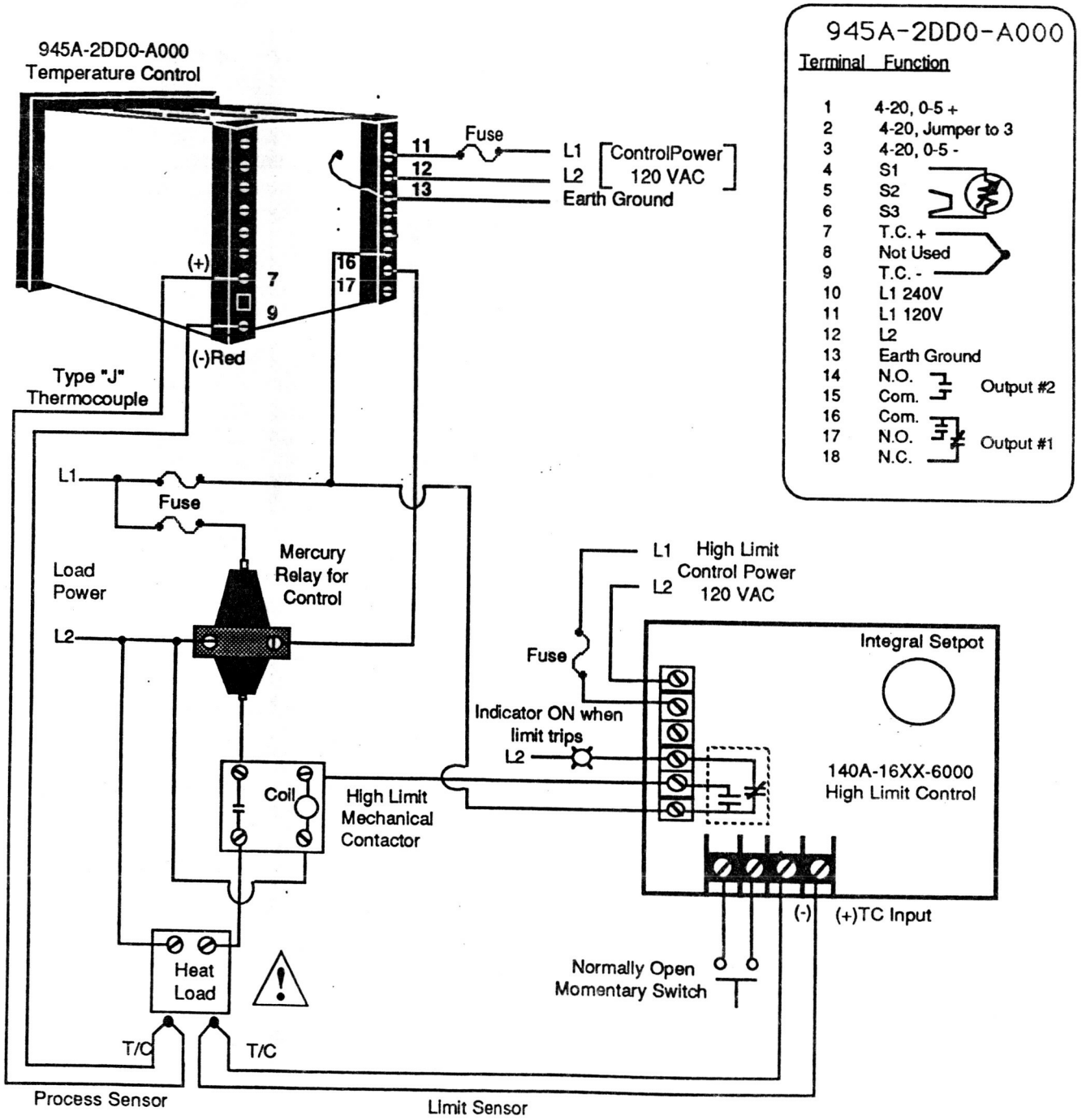
WARNING:

All wiring and fusing must conform to the National Electric Code NFPA70 and to any locally applicable codes. Contact your local board for additional information. Failure to observe NEC safety guidelines could result in injury to personnel.

CAUTION:

Watlow mercury relays are designed to be used only with resistive loads.

Figure 27 - System Wiring Example



Chapter 3

How to Use the Keys and Displays

Figure 28 - Series 945 Keys and Displays.

After 1 minute with no key activations, the control reverts to the process value in the upper display and the set point in the lower display.

Upper Display
Red, 0.56" (14 mm) high, seven segment, four digit LED display, indicating either process actual temperature, the operating parameter values, or an open sensor. When powering up, the Process display will be blank for 8 seconds.

Lower Display
Red 0.56" (14 mm) high, seven segment, four digit LED display, indicating the set point, operation parameters, menu parameters, and error or alarm codes.

L 1 & L2
When lit, these LED's tell you when Output 1 or Output 2 is energized. L2 only appears if your unit has the #2 Output type.

A1 & A2
When lit, these LEDs tell you when Alarm 1 or 2 is active. Only appears on those units with alarms option.

MODE Key
Steps the control through the Operating menu; also, in the Auto mode, enters new data selected.

UP Key
Increases the value of the displayed parameter. A single touch increases the value by one. Hold the key down to increase the value at a rapid rate. New data is self entering in 5 seconds.

DOWN Key
Decreases the value of the displayed parameter. A single touch decreases the value by one. Hold the key down to decrease the value at a rapid rate. New data is self entering in 5 seconds.

AUTO/MAN Key
Pressed once, it clears any latched alarms. If the key is pressed again within 5 seconds, the control toggles between the Auto and Manual mode. While in the Manual mode, percent power is always displayed in the lower display.

Front Panel Locking Screw
Secures or releases the control chassis from its case.

UP/DOWN keys
When pressed simultaneously for 3 seconds, the Setup Menu appears displaying the LOC parameter. At the LOC parameter, continue to press the UP/DOWN keys simultaneously, and the Calibration Menu will appear.

Auto/Manual LED
Lit when the control is in Manual operation. Press the key twice to enter Auto operation. A blinking Auto/Manual LED indicates that pressing the AUTO/MAN key toggles between Auto and Manual. After 5 seconds without pressing the AUTO/MAN key, the LED stops blinking, and returns to its previous state.

Chapter 4

How To Setup The Series 945

Setting up the Series 945 is a simple process. First configure the 945's features to your application in the Setup Menu, and then enter values in the Operating Menu. Use the MODE key to move through the menus and the UP/DOWN keys to select data.

At this point, enter the Calibration menu by pressing the UP/DOWN keys simultaneously for 3 seconds. Selecting US or SI under the dFL parameter determines the following: If selected as US, rate, reset, °F and proportional band in degrees will appear. In selected as SI, integral, derivative, °C and proportional band in % of span will appear. See Appendix II to change this parameter.

How to Set the DIP Switch

The Watlow Series 945 has a Dual In-line Package (DIP) switch inside the control on the A007-1954 circuit board (middle board). The location of the board and switches appear below. The switches are clearly numbered. When Switch #1 is ON, the Setup parameters can be viewed but not changed. Switch #2 is not used. The factory default is OFF.

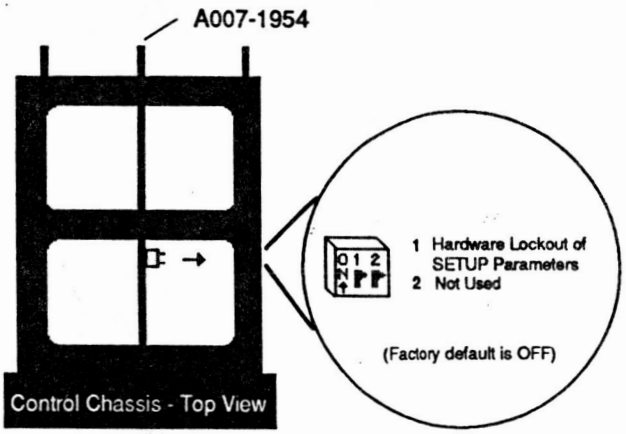


Figure 29 - DIP Switch Location and Orientation

Entering the Setup Menu

Enter the Setup Menu by pressing the UP/DOWN keys simultaneously for 3 seconds. The lower display shows the LOC parameter, and the upper display shows its current level. All keys are inactive until you release both keys. You can reach the LOC parameter from anywhere.

You will not see all parameters in this menu, depending on the unit's configuration and model number. After stepping through the menu it returns to the control set point parameter under the Operation menu.

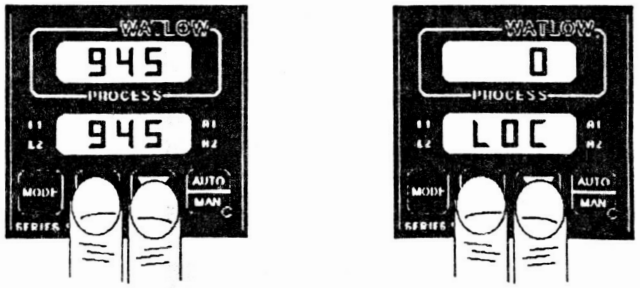


Figure 30 - Entering the Setup Menu

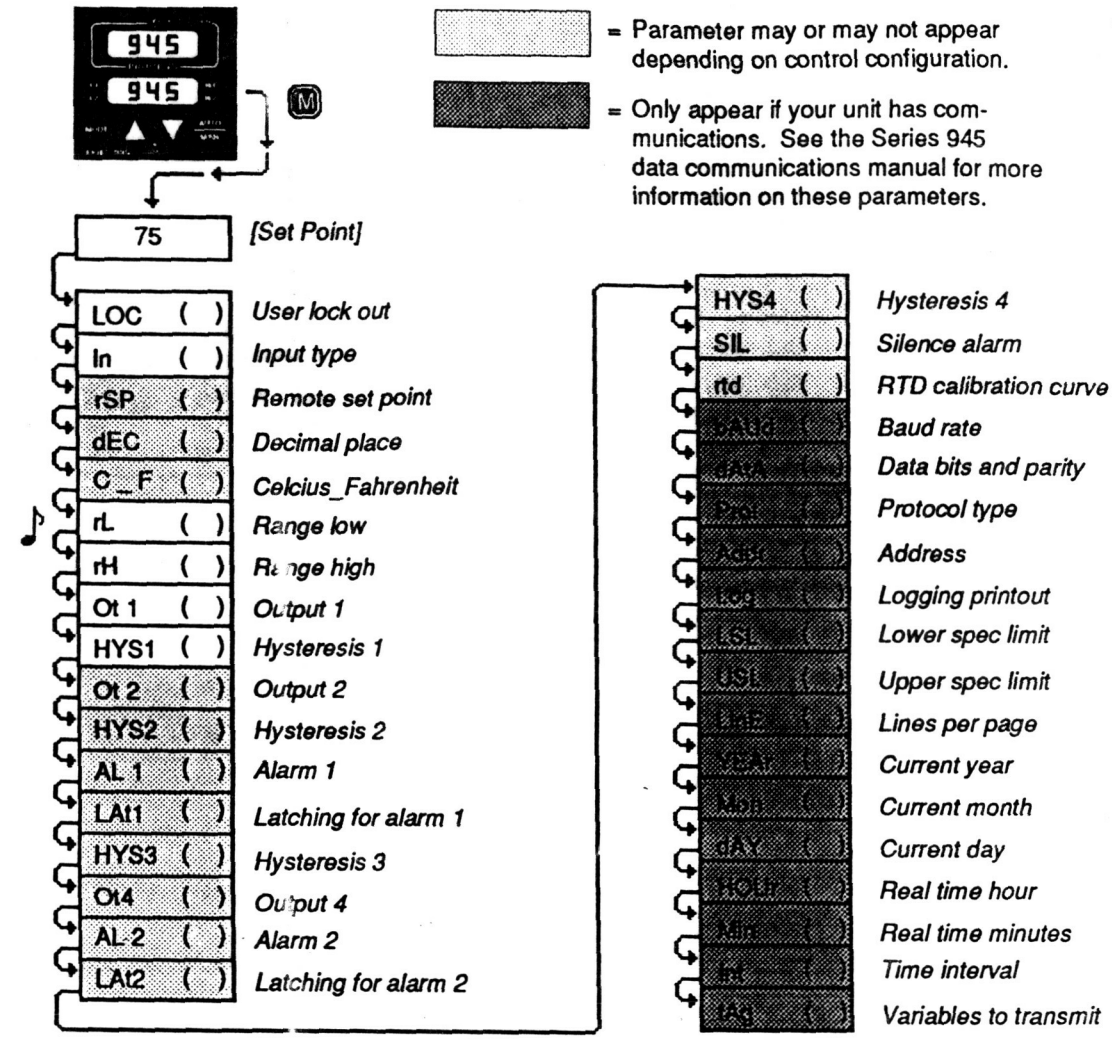


Figure 31 -
The Setup Menu

NOTE:

The rL and rH parameters are used to scale the display for process inputs, and/or will scale the retransmit range for process output. rL and rH also limit the range of the set point.

Setup Parameters

When you are at the top of the menu, the Series 945 displays the user level of operation in the upper display, and the LOC parameter in the lower display.

When you press the MODE key, the **value** of the next parameter appears in the upper display, and the prompt appears in the lower display. For units with process input, see the L-r parameter on Page 20 for how LOC is affected.

LOC

Lock: Selects the level of operator lockout. **Range:** 0 - 3 **Default:** 0

LOC 0: All operating parameters may be viewed or changed. Manual operation **is** permitted.

LOC 1: The set point, actual, and L-r (if rSP is enabled) are the only visible parameters, set point **is** adjustable in this level. Manual operation **is** permitted.

LOC 2: The set point, actual, and L-r (if rSP is enabled) are the only visible parameters, set point **is** adjustable in this level. Manual operation is **not** permitted.

LOC 3: The set point and actual are the only visible parameters, set point is **not** adjustable in this level of lockout. Manual operation is **not** permitted.

Input: Selects the sensor input type. Only those input types which are compatible with your unit will appear. See the model number information for your type.
Range: J, K (appears as H), t, n, c, r, S, b, Pt2, rtd, rt.d, 0-5, 420 **Default:** J or r

In

Remote Set Point: Enables models with process input capability to accept a remote set point signal from another device. This parameter only appears if In = Thermocouple or RTD. **Range:** OFF, 0-5, 420 **Default:** OFF

rSP

Decimal: Selects the location of the decimal point for all process related data. This parameter only appears if the In parameter is 0-5 or 420.
Range: 0, 0.0, 0.00 **Default:** 0

dEC

For RTD

— Not for thermocouple.

Celsius _ Fahrenheit: Selects the units of temperature measurement. This parameter only appears if the In parameter is a thermocouple or RTD input. Dependant on the dFL parameter. See Appendix II. **Range:** C or F **Default:** C or F

C _ F

Range Low: Selects the low end of the set point range. See the model number and specification information on the inside back cover, and Table 1 on Page 16 for sensor range values. Also used to set the low end of the process or remote set point input and/or the low end of the range for the retransmit output. 0.0VDC and 4mA represent Range Low (rL) for process inputs and outputs. Process inputs and outputs are linearly scaled between rL and rH.
Range: Sensor range low to rH **Default:** Low limit of sensor type

rL

Range High: Selects the high end of the set point range. See the model number and specification information on the inside back cover, and Table 1 on Page 16 for your sensor range values. Also used to set the high end of the process or remote set point input and/or the high end of the range for the retransmit output. 5.0 VDC and 20mA represent Range High (rH) for process input and output. Process inputs and outputs are linearly scaled between rL and rH.
Range: Sensor range high to rL **Default:** High limit of sensor type

rH

Output 1: Selects the output action for the primary output. Action is in response to the difference between set point and process variable. Select ht (heat) for reverse acting or select CL (cool) for direct acting. **Range:** ht, CL **Default:** ht

Ot1

Hysteresis 1: Selects the switching hysteresis for Output 1 when Pb1 = 0 (ON/OFF). See Page 18 for the Pb1 parameter.
Range: 1°F - 99°F 0.1°F - 9.9°F **Default:** 3°F
1°C - 55°C 0.1°C - 5.5°C
1Unit - 99 Units 0.1 Units - 9.9 Units

HYS1

Output 2: Selects the output action for the secondary output. Action in response to the difference between set point and process variable. Select ht (heat) for reverse acting or select CL (cool) for direct acting. This parameter only appears if you have a secondary output. **Range:** CL, ht, no **Default:** CL

Ot2

Hysteresis 2: Selects the switching hysteresis for Output 2 when Pb2 = 0 (ON/OFF). See Page 18 for the Pb2 parameter. This parameter only appears if you have a secondary output; it will not appear if Ot2 = no. **Range:** 1°F - 99°F
0.1°F - 9.9°F **Default:** 3°F
1°C - 55°C 0.1°C - 5.5°C
1Unit - 99 Units 0.1 Units - 9.9 Units

HYS2

AL1

Alarm 1: Determines whether the alarm type for Alarm 1 is process, deviation, or none. A process alarm is set at an absolute temperature. A deviation alarm follows or tracks the set point. This parameter only appears if your unit has alarms.
Range: Pr, dE, no **Default:** Pr

LAt1

Latching 1: Selects whether Alarm 1 is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. This parameter will not appear if AL 1 = no, or your unit does not have alarms. **Range:** LAt or nLA **Default:** nLA

HYS3

Hysteresis 3: Selects the switching hysteresis for Alarm 1. Appears if your unit has alarms and AL 1 = Pr or dE.

Range:			**Default:**
	1°F - 99°F	0.1°F - 9.9°F	3°F
	1°C - 55°C	0.1°C - 5.5°C	
	1Unit - 99 Units	0.1 Unit - 9.9 Units	

Ot4

Output 4: Selects Output 4 as retransmit of Process (PrOC) or Set Point (StPt). Hardware must be present. Scaling of the retransmit output is determined by rL and rH. **Range:** PrOC, StPt, no **Default:** PrOC

AL2

Alarm 2: Determines whether Alarm 2 type is process, deviation, or none. A process alarm is set at an absolute temperature. A deviation alarm follows or tracks the set point. This only appears if your unit has alarms.
Range: Pr, dE, no **Default:** Pr

LAt2

Latching 2: Selects whether Alarm 2 is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. Will not appear if your unit does not have alarms or AL1 = no. **Range:** LAt or nLA **Default:** nLA

HYS4

Hysteresis 4: Selects the switching hysteresis for Alarm 2. Appears if your unit has alarms and AL 2 = Pr or dE.

Range:			**Default:**
	1°F - 99°F	0.1°F - 9.9°F	3°F
	1°C - 55°C	0.1°C - 5.5°C	
	1Unit - 99 Units	0.1 Unit - 9.9 Units	

SIL

Silencing: Selects alarm silencing (inhibit) for Alarm 1. This parameter only appears when AL1 = dE. For more information see Chapter 5.
Range: On or OFF **Default:** OFF

rtd

RTD: Selects the RTD calibration curve for RTD inputs. Appears if In = rtd or rt.d. JIS = 0.003916Ω/Ω°C, DIN = 0.003850Ω/Ω°C.
Range: din or JIS **Default:** din

Any parameters that appear after RTD are related to data communications. See *How to Use Data Communications with the Watlow Series 945* for more information.

Table 1 - Input Ranges.

Input Type	Sensor Range Low	Sensor Range High
J	32°F/0°C	1382°F/750°C
K (appears as H)	-328°F/-200°C	2282°F/1250°C
t	-328°F/-200°C	662°F/350°C
n	32°F/0°C	2282°F/1250°C
c	797°F/425°C	4200°F/2315°C
Pt2	32°F/0°C	2543°F/1395°C
r	32°F/0°C	2642°F/1450°C
S	32°F/0°C	2642°F/1450°C
b	1598°F/870°C	3092°F/1700°C
rtd (1°)	-328°F/-200°C	1112°F/600°C
rt.d (0.1°)	-99.9°F/-99.9°C	392.0°F/200.0°C
0-5 (VDC)	-5.00/-50.0/-500	35.00/350.0/3500
420 (mA)	-5.00/-50.0/-500	35.00/350.0/3500

Setup Menu

Use this page as a master copy for configuring your Series 945.
Do not enter any values here; make photocopies instead.

Table 2 -
Setup Menu Prompts and Descriptions.

Parameter	Value	Range	Factory Default	Appears If:
LOC		0 - 3	0	
In		J, K (appears as H), t, n, c, Pt2, r, S, b, rtd, rt.d, 0-5, 420	J or r	
rSP		OFF, 0-5, 420	OFF	In = T/C or RTD
dEC		0, 0.0, or 0.00	0	In = 0-5 or 420
C_F		C or F	F	In = T/C or RTD
rL		rL to rH	Input dependent.	
rH		rH to rL	Input dependent.	
Ot1		ht or CL	ht	
HYS1		1°F - 99°F, 1°C - 55°C, 1U - 99U 0.1°F - 9.9°F, 0.1°C - 5.5°C, 0.1U - 9.9U	3°F	
Ot2		ht, CL or no	CL	Unit has secondary output
HYS2		1°F - 99°F, 1°C - 55°C, 1U - 99U 0.1°F - 9.9°F, 0.1°C - 5.5°C, 0.1U - 9.9U	3°F	Unit has secondary output Ot2 = ht or CL
AL1		Pr, dE or no	Pr	Unit has alarms
LAt 1		LAt or nLA	nLA	Unit has alarms and AL1 = Pr or dE
HYS3		1°F - 99°F, 1°C - 55°C, 1U - 99U 0.1°F - 9.9°F, 0.1°C - 5.5°C, 0.1U - 9.9U	3°F	Unit has alarms and AL1 = Pr or dE
Ot4		no, PrOC, StPt	PrOC	Hardware is present
AL 2		Pr, dE or no	Pr	Unit has alarms
LAt 2		LAt or nLA	nLA	Unit has alarms and AL2 = Pr or dE
HYS4		1°F - 99°F, 1°C - 55°C, 1U - 99U 0.1°F - 9.9°F, 0.1°C - 5.5°C, 0.1U - 9.9U	3°F	Unit has alarms and AL2 = Pr or dE
SIL		On or OFF	OFF	Unit has alarms & AL1 = dE
rtd		JIS or din	din	In = rtd or rt.d

Operation Menu

In the Operation menu, the 945 operates as a digital set point control. All outputs are turned OFF when set point is set to OFF.

NOTE:
The upper display will always return to the process value after 1 minute without key strokes.

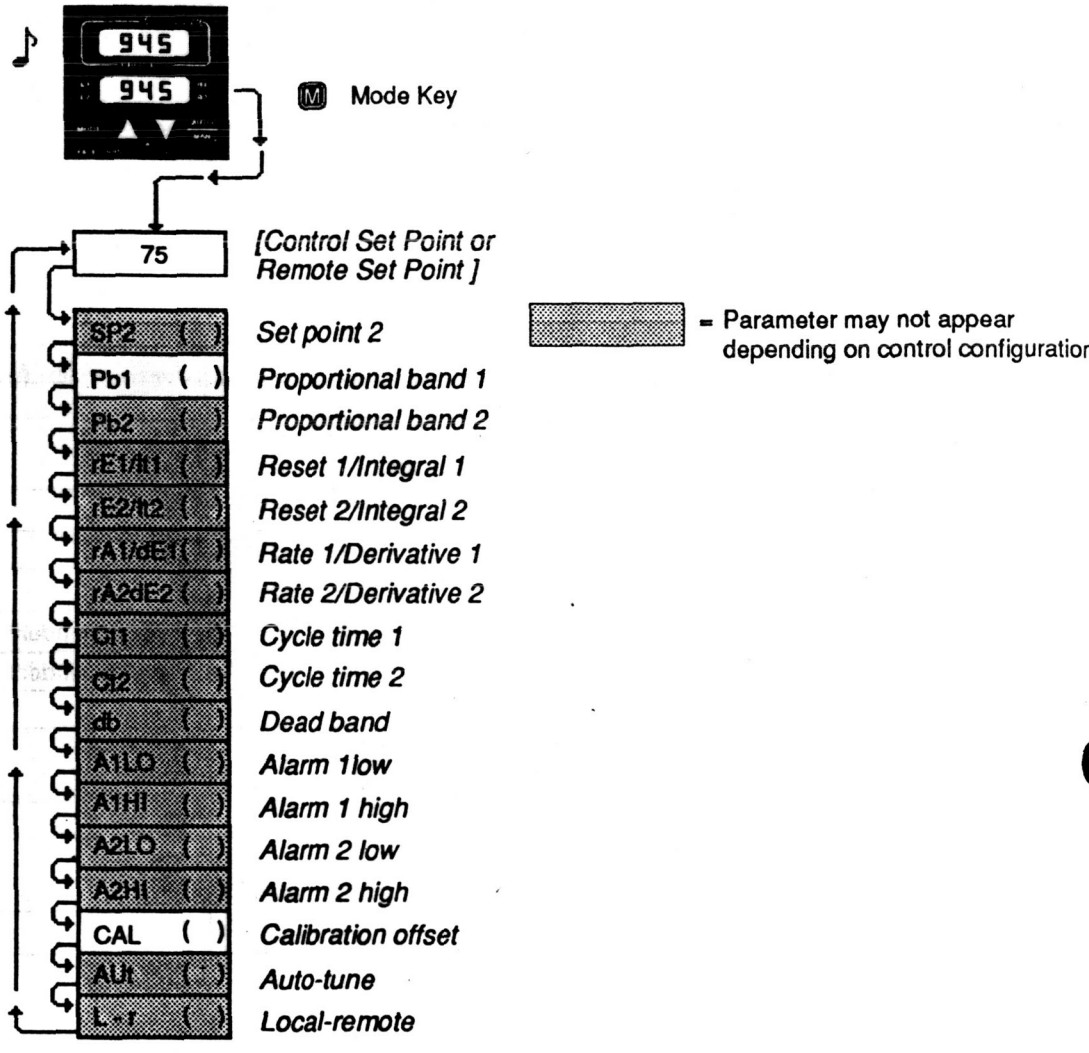


Figure 32 - The Operation Menu

Operation Parameters

75

Set Point 1 or Remote Set Point 1: Sets the operating set point for the control outputs. Appears if L-r = L, see Page 20. If L-r = R, this parameter represents the remote set point. **Range:** OFF / rL to rH **Default:** Dependent on input range

SP2

Set Point 2: Sets the operating set point for Output 2 when control mode is ht/ht or CL/CL. Appears when Ot1 and Ot2 are the same, and functions as an ON/OFF control. **Range:** rL to rH **Default:** Same as primary set point.

Pb1
Pb2

Proportional Band: Expressed in degrees, process units or % of span, within which a controller proportioning function is active for Output 1 or 2. When PbX = 0, it functions as an ON/OFF control. The switching differential is then determined by the corresponding HYSX parameter. Pb1 is always visible. Pb2 will not appear if your unit does not have Output 2, Ot2 = no, or Ot2 is the same value as Ot1. Also dependant on the dFL parameter in the Calibration menu.
If dFL = US: **Range:** 0 to 999°F/0 to 555°C/0 to 999 Units; 0.0 to 9.9°F/0.0 to 5.5°C/0.0 to 9.9 Units **Defaults:** *Pb1* = 25°F/2.5°F *Pb2* = 0
If dFL = SI: **Range:** 0 to 999.9% of span **Defaults:** *Pb1* = 3.0% *Pb2* = 0.0%

Reset /Integral1: A reset (integral) control action for Output 1 or Output 2 automatically eliminating offset, or "droop," between set point and actual process temperature. Will not appear if your unit does not have a secondary output. rE1/It1: Will not appear if Pb1 = 0. rE2/It2: Will not appear if Pb2 = 0, Ot2 = no, or Ot2 is the same configuration as Ot1. Either reset (rE) or integral (It) will appear depending on how the dFL parameter is set in the Calibration menu. See Appendix II. **Range:** 0.00 to 9.99 repeats/minute **Default:** 0.00

rE1/It1
rE2/It2

Rate/Derivative 1: The rate (derivative) function for Output 1 or Output 2. Rate or derivative is used to eliminate over shoot on start up, or after the set point changes. rA1/dE1: Will not appear if Pb 1 = 0. rA2/dE2: Will not appear if your unit does not have a secondary output, Pb2 = 0, Ot2 = no, or Ot2 is the same value as Ot1. Either rate (rA) or derivative (dE) will appear depending on how dFL is set in the Calibration menu. **Range:** 0.00 to 9.99 minutes **Default:** 0.00

rA1/dE1
rA2/dE2

Cycle Time 1 & 2: Time for a controller to complete one ON/OFF cycle for Output 1or Output 2; expressed in seconds. Ct1: Will not appear if Pb 1 = 0, or Output 1 is 4-20mA. Ct2: Will not appear if your unit does not have a secondary output, Pb2 = 0, Ot2 = no, or Ot2 is the same value as Ot1. **Range:** 1 to 60 seconds **Default:** 5

Ct1
Ct2

Dead Band: The area between Output 1 and 2 where no heating or cooling takes place in a heat/cool proportional control. Only appears if your unit is set up as a ht/CL or CL/ht unit. **Range:** ±0 to 99°F/0 to 55°C/0 to 99 Units; or ±0.0 to 9.9°F/0.0 to 5.5°C/0.0 to 9.9 Units **Default:** 0

db

Alarm 1 Low: Represents the low process alarm or low deviation alarm for Alarm 1. Will not appear if your unit does not have alarms and AL 1 = no.
If AL 1 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F
If AL 1 = Pr: **Range:** rL to A1HI **Default:** rL

A1LO

Alarm 1 High: Represents the high process alarm or high deviation alarm for Alarm 1. Will not appear if your unit does not have alarms and AL 1 = no.
If AL 1 = dE: **Range:** 0 to 999°F/0 to 999°C/0 to 999 Units **Default:** 999°F
If AL 1 = Pr: **Range:** A1LO to rH **Default:** rH

A1HI

Alarm 2 Low: Represents the low process alarm or low deviation alarm for Alarm 2. Will not appear if your unit does not have Alarm 2 and AL 2 = no.
If AL 2 = dE: **Range:** 0 to -999°F/0 to -999°C/0 to -999 Units **Default:** -999°F
If AL 2 = Pr: **Range:** rL to A2HI **Default:** rL

A2LO

Alarm 2 High: Represents the high process alarm or high deviation alarm for Alarm 2. Will not appear if your unit does not have Alarm 2 and AL 2 = no .
If AL 2 = dE: **Range:** 0 to 999°F/0 to 999°C/0 to 999 Units **Default:** 999°F
If AL 2 = Pr: **Range:** A2LO to rH **Default:** rH

A2HI

Calibration Offset: Adds or subtracts degrees from the input signal. **Range:** -180°F to 180°F/-100°C to 100°C/-180Units to 180 Units; or -180.0°F to 180.0°F/-100.0°C to 100.0°C **Default:** 0

CAL

AUt

Auto-Tune: Initiates auto-tune for Output 1. This parameter appears if Ot 1 =ht.
Range: 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

L-r

Local-Remote: Selects a local or remote set point for the Series 945. This parameter only appears if the LOC parameter = 0, 1 or 2, and rSP = 0-5 or 420. If L-r = r, the remote set point will be displayed in place of the internal set point.
Range: L = Local operation r = remote operation **Default:** L

Operation Menu

Use this page as a master copy for your Series 945 Operation parameters.
Do not enter any values here; make photocopies instead.

Table 3 - Operation Menu Prompts and Descriptions.

Parameters	Value	Range	Factory Default	Appears If:
Set Point 1 or Remote Set Point 1			rL to rH	75°F
SP2		rL to rH	Primary set point.	Ot1 = Ot2, Pb1 = 0
Pb1		0 - 999°F/0 - 555°C/0 - 999U 0 - 99.9°F/0 - 55.5°C/0 - 99.9U 0=ON/OFF control. HYS1 =swtch. diff.	25°F	
Pb2		Same as Pb1.	0°F	Ot2 = ht or CL Ot2 ≠ Ot1
rE1/It1		0.00 to 9.99 repeats/min. 0.00 = No Reset.	0.00 rpt/min.	Pb1 ≠ 0
rE2/It2		Same as rE1/It1.	0.00 rpt/min.	Pb2 ≠ 0, Ot2 ≠ Ot1 Ot2 = ht or CL
rA1/dE1		0.00 to 9.99 min. 0.00 = No Rate.	0.00 min.	Pb1 ≠ 0
rA2/dE2		Same as rA1/dE1.	0.00 min.	Pb2 ≠ 0, Ot2 ≠ Ot1 Ot2 = ht or CL
Ct1		1 to 60 seconds	5 seconds	Pb1 ≠ 0, Output1 ≠ 420
Ct2		1 to 60 seconds	5 seconds	Pb2 ≠ 0, Ot2 ≠ Ot1, Ot2 = ht or CL
db		±0 - 99°F/±0 - 55°C/0 - 99U. ±0.0 - 9.9°F/0.0 - 5.5°C/0.0 - 9.9U	0	Ht/CL or CL/Ht
A1LO Deviation **dE** Process **Pr**		-999° to 0° rL to A1HI	-999° rL	AL1 = Pr, dE Unit has alarms
A1HI Deviation **dE** Process **Pr**		0° to 999° A1LO to rH	999° rH	AL1 = Pr, dE Unit has alarms
A2LO Deviation **dE** Process **Pr**		-999° to 0° rL to A2HI	-999 rL	AL2 = Pr, dE Unit has Alarm 2
A2HI Deviation **dE** Process **Pr**		0° to 999° A2LO to rH	999° rH	AL2 = Pr, dE Unit has Alarm 2
CAL		±180°F/±100°C/±180U	0	
AUt		0-3	0	Ot1 = ht, L-r = L
L-r		L or r	L	rsP = 0-5 or 420

Chapter 5

How to Tune and Operate

Tuning - Automatic

The auto-tuning procedure operates on a thermal response value — slow, medium, or fast. Use the slow thermal response when your process does not reach set point too rapidly, or if it usually does not exceed set point a lot. A fast thermal response produces a rapid temperature change over a short period of time.

Once the auto-tune sequence has begun, the Output 1 heat proportional band is set to 0 and the control goes into an ON/OFF mode of control at 90% of the established set point. The displayed set point remains unchanged.

The cool output remains off for the tuning duration. Once the control learns the thermal system response, it returns to a standard PID control installing PID values automatically set as a result of auto-tuning. Output 2 cool PID values are unaffected by auto-tuning, and remain at their factory default settings. See Manual tuning below. Tuning is complete within 80 minutes. Any change of the set point, while in auto-tune, re-initiates the auto-tune procedure.

The Series 945 will **not** Auto-tune while in remote set point. Transferring from local to remote set point takes the 945 out of auto-tune.

To start auto-tuning:

1. **Press the MODE key** until the **AUt** parameter appears in the data display.
2. **Select a thermal response value** using the UP/DOWN keys, 1=slow, 2=medium, and 3=fast. A thermal response value of 2 satisfactorily tunes most thermal systems.
3. **Press the MODE key.** While the control is in the tuning mode, the lower display alternately displays the normal information and the prompt **At**. The time between alternations is 1 second.
4. **When tuning is complete,** the displays return to their previous state and **AUt** reverts to 0. The 945 installed appropriate PID tuning parameters and saved them in the non-volatile memory. **If a mechanical relay or contactor is switching power to the load, a longer cycle time may be desirable to minimize wear on the mechanical components.**

To abort auto-tuning, the operator must reset the **AUt** parameter to 0, press AUTO/MAN twice, or cycle power off and on. In all cases, aborting auto-tune restores all values to those previous to auto-tuning.

Tuning - Manual

For optimum control performance, tune the Series 945 to your thermal system. The tuning settings here are for a broad spectrum of applications; your system may have somewhat different requirements. **NOTE: This is a slow procedure, taking from minutes to hours to obtain optimum value.**

♪ **NOTE:**

Tune heating outputs at a set point above ambient temperature.
Tune cooling outputs at a set point below ambient temperature.

1. **Apply power to the Series 945** and enter a set point. Begin with these Operation parameters: **Pb** = 1, **rE/It** = 0.00, **rA/dE** = 0.00, **Ct** = 5, **CAL** = 0, **AUt**= 0.

2. **Proportional Band Adjustment** : Gradually increase **Pb** until the upper display temperature stabilizes to a constant value. The process temperature may not be right on set point because the initial reset value is 0.00 repeats per minute.

3. **Reset/Integral Adjustment**: Gradually increase **rE/It** until the upper display temperature begins to oscillate or "hunt." Then slowly decrease **rE/It** until the upper display stabilizes again near set point.

4. **Cycle Time Adjustment**: Set **Ct** as required. Faster cycle times sometimes achieve the best system control. However, if a mechanical contactor or solenoid is switching power to the load, a longer cycle time may be desirable to minimize wear on the mechanical components. Experiment until the cycle time is consistent with the quality of control you want. Ct will not appear on units with a process output.

5. **Rate/Derivative Adjustment**: Increase **rA/dE** to 1.00 minute. Raise set point by 20° to 30°F, or 11° to 17°C, observe the system's approach to set point. If the load temperature overshoots set point, increase **rA/dE** to 2.00 minutes.

   Next raise set point by 20 to 30°F, or 11 to 17°C and watch the approach to the new set point. If you increase **rA/dE** too much, approach to set point will be very sluggish. Repeat as necessary until the system rises to the new set point without overshooting or approaching the set point too slowly.

6. **Calibration Offset Adjustment:** You may want your system to control to a temperature other than the value coming from the input sensor. If so, measure the difference between that temperature (perhaps at another point in the system) and the process value showing in the upper display. Then enter the **CAL** offset value you want. Calibration offset adds or subtracts degrees from the value of the input signal.

Manual and Automatic Operation

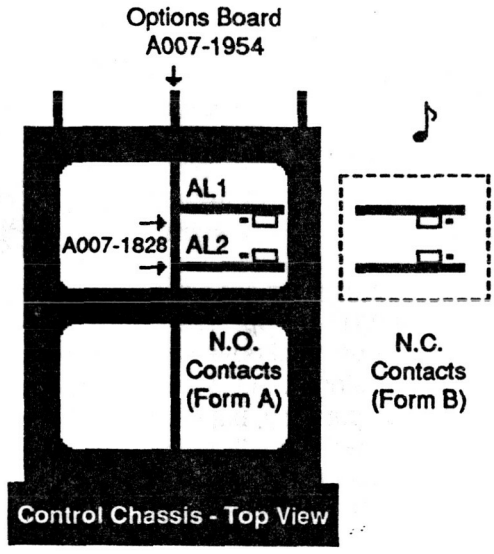
To change from manual to auto operation, press AUTO/MAN twice.
Manual operation provides open loop control of the outputs from -100% to 100% power. The 945 allows a negative output value only with a CI (Cool) selection on either Ot1 or Ot2. Automatic operation provides closed loop ON/OFF or PID control. When the operation transfers from a closed loop to an open loop, the 945 retains the power level from the closed loop control. When the 945 returns to closed loop control, it restores the previous set point temperature.

The LED on the AUTO/MAN key indicates auto or manual operation. When the LED is ON, the control is in manual operation. When the LED is OFF, it is in Automatic operation. When the LED flashes, press the key again within five seconds to complete the change in operation. If the sensor is open and LOC = 0 or 1, the Series 945 switches to manual operation, if the output was stable before the break occurred.

When transferring from auto to manual operation, the control output(s) remains stable ("bumpless," smooth transition). When transferring from manual to automatic operation, the control output(s) may change significantly. In manual, the output value appears in the lower display; in automatic operation, the set point appears.

Changing the Position of an Alarm Jumper

1. Remove power from the control. Turn the front panel screw 90° counterclockwise.
2. Grip the front panel bezel and pull it straight out from the control case. The control chassis will come out of the case as you pull the bezel.
3. Set the jumper to the position you want. See below for jumper location.
4. Return the control chassis to the case. Be sure you have it oriented correctly. Press firmly, but gently, to seat the chassis.



NOTE:
Depending on the unit you order, your control may have 0, 1, or 2 alarm jumpers.

Figure 33 - Alarms Jumper Location.

The alarm output de-energizes upon an alarm or power interruption to the 945's power supply. When you select **N.O. Contacts**, the contact is open when an alarm occurs. When selecting **N.C. Contacts**, the contact closes when an alarm occurs.

Using Alarms

The Series 945 has two alarm types, Process or Deviation. A **Process alarm** sets an absolute temperature. When the process exceeds that absolute temperature limit an alarm occurs. The Process alarm set points may be independently set high and low.

A **Deviation alarm** alerts the operator when the process strays too far from set point. The operator can enter independent high and low alarm settings. The reference for the deviation alarm is the set point. Any change in set point causes a corresponding shift in the deviation alarm. **Example:** If your set point is 100°F, and a deviation alarm set at +7°F as the high limit, and -5°F as the low limit, the high alarm trips at 107°F, and the low alarm at 95°F. If you change the set point to 130°F, the alarms follow the set point and trip at 137°F and 125°F.

Both process and deviation alarms can be latching or non-latching. When the alarm condition is removed a **non-latching alarm automatically** clears the alarm output. You must **manually clear** a **latching alarm** before it will disappear.

Flashing 'LO" or "HI" in the lower display indicates an alarm. The lower display alternately shows information from the current parameter and the "LO" or "HI" alarm message at one second intervals. The alarm output is de-energized and the A1 or A2 LED is lit.

To clear an alarm...

- **First correct the alarm condition, then...**
  - **If the alarm is latching...**
    Clear it manually; press AUTO/MAN once as soon as the process temperature is inside the alarm limit according to the HYSX parameter.
  - **If the alarm is non-latching...**
    The alarm will clear itself automatically as soon as the process temperature is inside the alarm limit according to the HYSX parameter.

Figure 34 - Alarm Display Examples

Alarm Silencing for alarm output A1 is available with the deviation alarm. This overrides alarm A1 during power up. The **non-latching** mode automatically enables alarm output A1 on initial power up. In the **latching** mode, manually disable the alarm by pressing AUTO/MAN once. In both cases alarm silencing disables the A1 alarm output relay, but the A1 LED displays the alarm condition until the process value is within the "safe" region of the deviation alarm band. Once the process value crosses into the "safe" region, both a latching or a non-latching alarm is ready. Any future deviation outside this safe band triggers an alarm.

NOTE:
An alarm display will be masked by an error condition or when the control is in the Calibration or Setup Menus.

Error Code Messages

WARNING:
Electrical noise or a noise event, vibration or excess environmental moisture or temperature may cause Series 945 errors to occur. If the cause of an error is not otherwise apparent, check for these.

Four dashes, "- - - -", in the upper display indicate a Series 945 error. The error code is visible in the lower display.

Figure 35 - Error Code Display Example

Er 1 - Sensor overrange error

The sensor input generated a value higher than that allowed for the range of the sensor, or the A/D circuitry malfunctioned. Enter a valid input. The A/D value is above the range limits, but within the A/D conversion limits. Make sure the In parameter matches your sensor.

Er 2 - Sensor underrange error

The sensor input generated a value lower than that allowed for the range of the sensor, or the A/D circuitry malfunctioned. Enter a valid input. The A/D value is below the range limits, but within the A/D conversion limits. Make sure the In parameter matches your sensor.

Er 3 - Ambient error
Check the specification for the ambient temperature range.

Er 4 - Configuration error
The unit's microprocessor is faulty; call the factory.

Er 5 - Non volatile checksum error
The nonvolatile memory checksum discovered a checksum error. Unless a momentary power interruption occurred while the unit was storing data, the nonvolatile memory is bad. Call the factory.

Er 6 - A/D underflow error
The A/D circuit is underrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and functions properly, call the factory. The A/D underrange voltage is too low to convert an A/D signal. Make sure the In parameter matches your sensor.

Er 7 - A/D overflow error
The A/D circuit is overrange. An open or reversed polarity sensor is the most likely cause. Check the sensor; if the connection is good, and functions properly, call the factory. The A/D overrange voltage is too high to convert an A/D signal. Make sure the In parameter matches your sensor.

Error Code Actions

- **Error codes Er 1, Er 2, Er 3, Er 6, or Er 7 will result in these conditions:**
  - **If operator access is LOC 0 or 1...**

  ...and the control was in AUTO operation when the error occurred, it goes into manual (% power) operation. If the output power is less than 75% power, and a <5% change in power within the last two minutes, the 945 switches into manual operation at the last Automatic power level. If the control was in manual operation, it remains there. (Press AUTO/MAN twice to see the error code.) The alarm output (if present) is in its alarm state (LED lit). The upper display reads "- - - -". The lower display indicates the error code.

  If the control was operating with stable output values when the error occurred, it continues to operate at those levels on a % power basis. If output values were not stable, the control outputs go to 0% power (OFF).

  - **If operator access is LOC 2 or 3...**
    The control remains in AUTO operation and the outputs go OFF. AUTO/MAN and MODE are inactive. The UP/DOWN keys may be used simultaneously to enter the Setup Menu. The alarm output (if present) is in its alarm state (LED lit). The Upper display reads "- - - -". The Lower display indicates the error code.

  - **To clear a corrected error...**
    - Cycle power or MODE through Setup until you return to the set point.

- **Error codes Er 4 or Er 5 will result in these conditons:**
  - The control is in AUTO operation with both outputs OFF.
  - The alarm outputs are in their alarm state (de-energized with the LED lit).
  - The upper display indicates the process value.
  - The lower display indicates the error code.
  - All keys are inactive.
  - All Setup Menu parameters return to default values.
  - The above conditions occur regardless of the LOC value, or the presence of the Setup or Calibration Menus.

- **To clear a corrected error...**
  - Cycle power to the control.

Appendix 1

Noise and Installation Guidelines

For wiring guidelines , refer to the IEEE Standard No. 518-1982, available from IEEE, Inc. 345 East 47th Street, New York, NY 10017.

Noise Sources

- Switches and relay contacts operating inductive loads such as motors, coils, solenoids, and relays, etc.
- Thyristors or other semiconductor devices which are not zero crossover-fired (randomly-fired or phase angle-fired devices).
- All welding machinery and heavy current carrying conductors.
- Fluorescent and neon lights.

Decreasing Noise Sensitivity

- Physical separation and wire routing must be given careful consideration in planning the system layout. For example, A.C. power supply lines should be bundled together and physically kept separate from input signal lines (sensor lines). A 12" (305 mm) minimum separation is usually effective. Keep all switched output signal lines (high power level) separate from input signal lines (sensor lines). Cross other wiring at 90° angles whenever crossing is unavoidable.
- Look at the system layout; identify and locate electrical noise sources such as solenoids, relay contacts, motors, etc. Route the wire bundles and cables as far away as possible from these noise sources. Don't mount relays or switching devices close to a microprocessor control. Don't have phase angle-fired devices in the same electrical enclosure or on the same power line with the control.
- Shielded cables should be used for all low power signal lines to protect from magnetic and electrostatic coupling of noise. Some simple pointers are:
  - ◊ Run low level signal lines unbroken from signal source to the control circuit.
  - ◊ Connect a shield to the control circuit common at the control end only. Never leave shields unconnected at both ends or connect both shield ends to a common ground.
  - ◊ Maintain shield continuity at daisy chain connection points by reconnecting the broken shield.
  - ◊ Assume no electrostatic shielding when using the shield as a signal return. If you must, use triaxial cable (electrostatically shielded coaxial cable).
- Twisted pair wire should be used any time control circuit signals must travel over two feet, or when they are bundled in parallel with other wires.
- Select the size or gauge of wire by calculating the maximum circuit current and choose the gauge meeting that requirement. Using larger wire sizes than required generally increases the likelihood of electrostatic (capacitance) coupling of noise.
- Eliminate ground loops in the entire control system. You can spot the obvious loops by studying the "as-built" wiring diagram. There are also not-so-obvious ground loops resulting from connecting internal circuit commons in the manufacturer's equipment.
- Do not daisy chain A.C. power (or return) lines, or output signal (or return) lines to multiple control circuits. Use a direct line from the power source to each input requiring A.C. power. Avoid paralleling L1 (power lead) and L2 (return lead) to load power solenoids, contactors, and control circuits. If an application uses L1 (power lead) to switch a load, L2 (return lead) has the same switched signal and could couple unwanted noise into a control circuit.

- Tie all ground terminals together with one lead (usually green wire) tied to ground at one point. Don't connect ground to the control case if the control is in a grounded enclosure (preventing ground loops).
- Do not confuse chassis grounds (safety ground) with control circuit commons or with A.C. supply L2 (return or neutral line). Each return system wiring must be separate. Absolutely never use chassis ground (safety) as a conductor to return circuit current.

Eliminating Noise

- Use "snubbers" ("QUENCHARC™") to filter out noise generated by relays, relay contacts, solenoids, motors, etc. A snubber is a simple filter device using a 0.1µf, 600 volt, non-polarized capacitor in series with a 100Ω, 1/2 watt resistor. The device can be used on A.C. or D.C. circuits to effectively dampen noise at its source.
- The general purpose Watlow snubber, described above, is 0804-0147-0000. For other "QUENCHARC" sizes contact:

  PAKTRON
  P.O. Box 5439
  Lynchburg, VA 24502
  Phone: 804/239-6941

- A Metal Oxide Varistor (MOV) can be used to limit voltage "spikes" that occur on the A.C. supply lines as a result of lightning strikes, switching large motors, etc. The MOV is available in several varieties and for 115 or 230 volt lines. The device dissipates the voltage "spikes" to ground and in doing so repeatedly, deteriorates its ability to function. MOVs have a limited life. See Table 4.
- "Islatrols" and other similar power line filters are designed to carry the power for the control circuit and "buffer" the control circuit from A.C. line noise. Devices like the Islatrol use media (electromagnetic filtering) other than electric circuits to filter out electrical noise. Take care in matching the power capabilities of the filter with power demands of the circuit. Keep line filters as close to the control as possible to minimize the area for interference pick up.
- Islatrols are available from:

  Control Concepts Corporation
  328 Water Street
  P.O. Box 1380
  Binghamton, NY 13902-1380
  Phone: 607/724-2484

I - 101 (1A, 120VAC) I - 105 (5A, 120VAC) I - 115 (15A, 120VAC)
I - 202 (2.5A, 208/240VAC) I - 207 (7.5A, 208/240VAC)

- The ultimate protection is an "uninterruptable" power supply. This "senses" the A.C. power line; when the line fluctuates, a battery powered 60Hz inverted circuit takes over, supplying power within one-half to one cycle of the A.C. line; very expensive.

Checking for Ground Loops

To check for ground loops, disconnect the ground wire at the ground termination. Measure the resistance from the wire to the point where it was connected. The ohmmeter should read a high ohm value. If you have a low ohm value across this gap, there is at least one ground loop present in your system.

Or check for continuity; your reading should be "open." If you do find continuity, begin looking for the ground loops. Begin disconnecting ground in the system one at a time, checking for continuity after each disconnection. When continuity reads "open" you have eliminated the ground loop(s). Also, as you reconnect grounds, keep making the continuity test. It is possible to reconnect a ground loop.

Noise Suppression Devices Available From Watlow

Watlow Controls stocks a few key noise suppression parts. You may order these by calling your local Watlow distributor.

Table 4 - Noise Suppression Device Ratings

Item	Electrical Ratings	Part Number
Common Mode Line Filter	250V, 3 Amp	0804-0196-0000
Differential Mode Line Filter	Refer to the Islatrol listing above.	
Metal Oxide Varistor	150V, 80 Joule	0802-0273-0000
MOV 130V, 38 Joule	0802-0304-0000	
MOV 275V, 75 Joule	0802-0266-0000	
MOV275V, 140 Joule	0802-0405-0000	

Line Filtering Configurations For Controls

These three diagrams show filter configurations for removing input power noise. Choose the one best suited for your system. For very dirty or critical applications - use a microcomputer-regulated power supply or Uninterruptable Power Supply (U.P.S.). Don't fasten common mode line filters or filters with metal cases to metal at ground potential. This prevents ground loops and maintains filter effectiveness.

♪ 1 NOTE:

Keep filters 12" (305 mm) or less from the control. Minimize the line distance where noise can be reintroduced to the control.

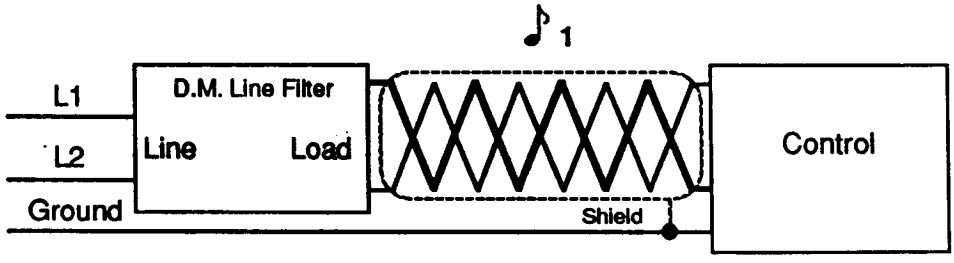


Figure 36 - Differential Mode Filter Wiring

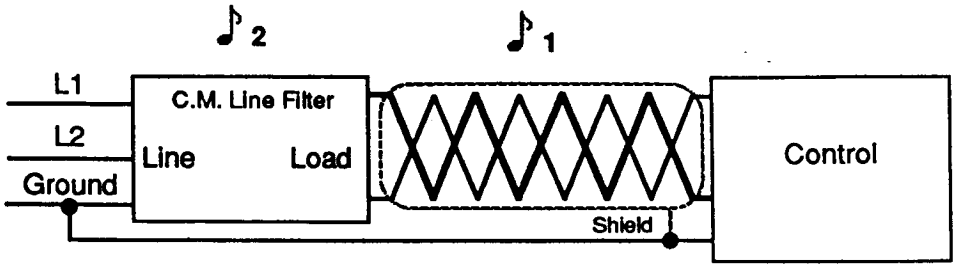


Figure 37 - Common Mode Filter Wiring

♪ 2 NOTE:

To prevent ground loops do not fasten common mode line filters or filters with metal that is at ground potential. Doing so will reduce filter effectiveness.

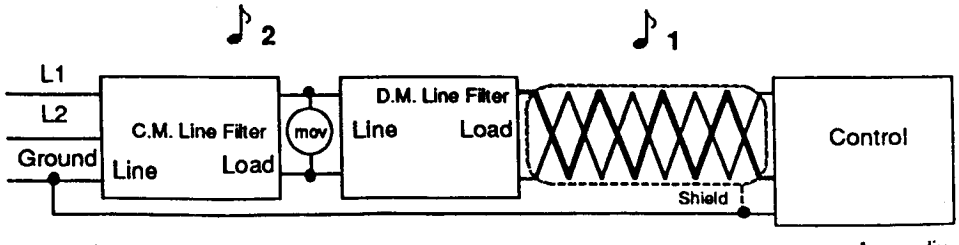


Figure 38 - Combination Differential/Common Mode Filter Wiring

Appendix 2

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

Entering the Calibration Menu

Enter the Calibration Menu to change the configuration of the dFL (default language) parameter. Several parameters are dependent on the dFL parameter, they are listed below. It is a good idea to change this parameter, if necessary, before entering the Setup menu. The factory configures your unit to your preference, but can be changed at any time.

In the Calibration menu, various input signals must also be supplied in order for the control to go through its auto calibration. The calibration menu can only be entered from the LOC parameter in the Setup menu. Press the UP/DOWN keys simultaneously for 3 seconds (± 1 second). The CAL parameter appears in the lower display with "no" in the upper display.

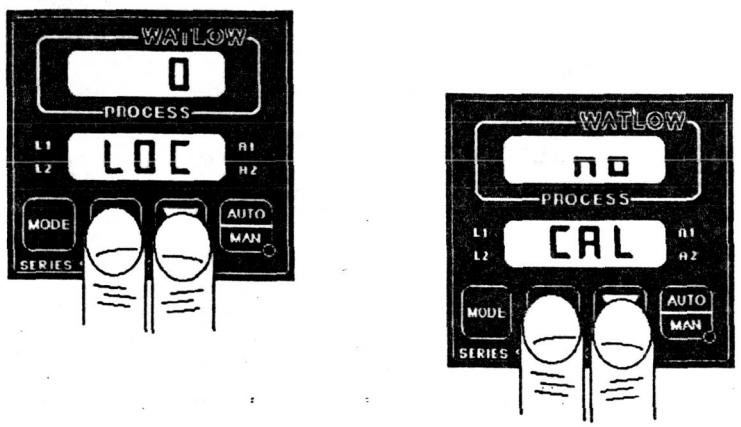


Figure 39 - Entering the Calibration Menu.

Any inadvertent change in the displayed data, when pressing the UP/DOWN keys, is ignored. Calibration values are not retained unless you are in the MANUAL mode. Press the UP/DOWN keys to change the upper display to "YES." Press the MODE key to enter the calibration sequence.

NOTE:
Calibration values are not retained unless you are in the MANUAL mode. Do not enter the MANUAL mode until you are at the correct input parameters.

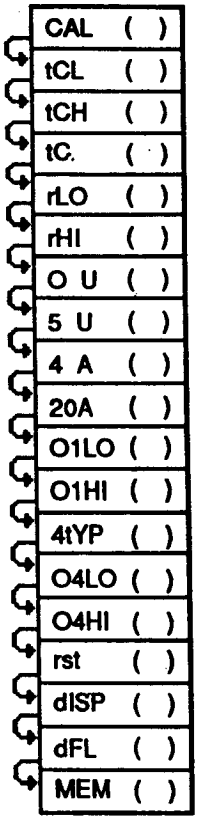
Upon entering the calibration menu, the top display window indicates CAL. The upper display continues to indicate CAL (with the exception of calibration of the 4-20mA output) while the operator walks through the entire calibration parameter list. While calibrating the 4-20mA output, the upper display contains a numeric value to be slewed up or down until the output value is correct. The control uses the lower display to prompt the user as to what the input should be The rSt parameter restores the factory calibration values to the Series 945. If you calibrate your control incorrectly, you have the option to default to the original values. Once you leave the CAL menu, the values are entered.

NOTE:
While in the Calibration Menu, all outputs are OFF, except the 4-20mA output.

The dFL parameter allows you to select either U.S. parameters which include displaying rate, reset, °F, and proportional band in degrees or units, or select SI (System International). The parameters displayed here are integral, derivative, °C, and proportional band in % of span.

Once the information has been properly established and maintained for 5 to 10 seconds, the MODE key may then be used to display the next parameter. After the final input is established, press the MODE key twice to return the unit to the configuration menu at the top of the parameter list.

Calibration Menu



YES to calibrate, No skips to display test.

Input 0.00mV for low thermocouple input.

Input 50.00mV (16.035 for r, S or b units) for high thermocouple input.

Connect a "J" T/C compensator, with inputs shorted. T/C units only.

Connect the JIS RTD low resistance per model number.

Connect the JIS RTD high resistance per model number.

Set the voltage source to 0.000 volts.

Set the voltage source to 5.000 volts.

Set the current source to 4.00mA.

Set thecurrent source to 20.00mA.

Press the UP/DOWN keys until Output 1 reads process low.

Press the UP/DOWN keys until Output 1 reads process high.

Factory select for Output 4 type.

Press the UP/DOWN keys until Output 4 reads process low.

Press the UP/DOWN keys until Output 4 reads process high.

Restores factory calibration values.

Factory use only.

Select US (rate, reset, proportional band in degrees or units, °F) or SI (integral, derivative, proportional band in % of span, °C).

Factory use only.

Figure 40 - Calibration Menu

Before attempting to calibrate, make sure you have the proper equipment called for in each procedure.

The Series 945 is calibrated and tested before leaving the factory.

Thermocouple Field Calibration Procedure

Equipment Required:

- Type "J" or "R" Reference Compensator with reference junction at 32°F/0°C, ***OR*** Type "J" or "R" Thermocouple Calibrator set at 32°F/0°C.
- Precision millivolt source, 0-50mV min. range, 0.01mV resolution

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals.
2. Connect the millivolt source to Terminal #9 Negative and Terminal #7 Positive on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29.
4. Press AUTO/MAN twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in MANUAL mode only when you are in the correct parameters. See Figure 40.
5. At **tcL**, enter 0.00mV from the millivolt source to the control. Allow 10 seconds to stabilize. Press MODE.
6. At **tcH**, enter 50.00mV for type "J" units or 16.035mV for type "R" units from the millivolt source to the 945. Allow at least 10 seconds to stabilize. Press MODE.
7. At **tc**, disconnect the millivolt source, and connect the reference compensator or T/C calibrator to Terminal #9 Negative, and Terminal #7 Positive on the 945 terminal strip. Allow 10 seconds to stabilize. The unit leaves CAL if 1 minute passes between key activations. Press AUTO/MAN twice to exit the MANUAL mode. To conclude, advance to the next prompt or exit the CAL menu.

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See Setup, and Operation Tables, Pages 18 and 20.

RTD Field Calibration Procedure

Equipment Required:

- 1KΩ precision decade resistance box with 0.01 ohms resolution.

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals.
2. Connect the decade resistance box to Terminal #4, 5 and 6 on the ter-minal strip. Use regular 20 - 24 gauge wire of the same length and type.
3. Apply power to the unit and allow warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press MODE until **rLO** s displayed.
4. Press AUTO/MAN twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in MANUAL mode only when you are in the correct parameters. See Figure 40.
5. At **rLO** set the decade resistance box to the correct low setting below. This can be calibrated to JIS or DIN. Allow 10 seconds to stabilize. Press MODE.

	Calibration	Low	High
945A-2XX0-0000	1°	17.31	317.33
945A-3XX0-0000	0.1°	59.59	177.13

6. At **rHI**, set the decade resistance box to the correct high setting. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations. Press AUTO/MAN twice to exit the MANUAL mode. To conclude, advance the MODE key to the next prompt or exit the CAL menu.

IMPORTANT:

When the MANUAL LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next parameter before changing the calibration equipment.

Table 5 - RTD Settings.

0 - 5 Volt Output Field Calibration Procedure

Equipment Needed: • 20KΩ, 1/4 watt, 10% resistor • 4 1/2 digit digital multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals.
2. Connect the multimeter across the 20KΩ resistor to Terminal #17 Positive and #18 Negative on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power and allow warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press the MODE key until **O1LO** is displayed.
4. Press AUTO/MAN twice to enter the MANUAL mode. The unit is calibrating when the MANAUL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **O1LO** parameter, the multimeter should read approximately 0V. Allow at least 10 seconds to stabilize.
6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for -0.2V ±0.1V. Press the MODE key.
7. At **O1HI**, the multimeter should read approx.5V. Allow 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations.
8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 5.2V ± 0.1V.
9. Press the AUTO/MAN key twice to exit the MANUAL mode. To conclude, advance the MODE key to the next prompt or exit the CAL menu.

NOTE:

Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Tables, Pages 18 and 20.

IMPORTANT:

When the MANUAL LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next prompt before changing the calibration equipment.

4-20mA Output Field Calibration Procedure

Equipment Required: • 470Ω, 1/2 watt 10% resistor. • 4 1/2 digit digital multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals.
2. Connect the multimeter in series with the 470Ω resistor to Terminal #17 Positive and #18 Negative on the 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press MODE until **O1LO** is displayed.
4. Press the AUTO/MAN key twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **O1LO** parameter, the multimeter should read approximately 4mA. Allow at least 10 seconds to stabilize.
6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 3.85mA ± 0.10mA. Press the MODE key.
7. At **O1HI**, the multimeter should read approx. 20mA. Allow 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations.
8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 20.15mA ±0.10mA.
9. Press the AUTO/MAN key twice to exit the MANUAL mode. To conclude,advance the MODE key to the next prompt or exit the CAL menu.

0 - 5 Volt Input Field Calibration Procedure

Equipment Required:

- Precision voltage source 0-5 volt minimum range with 0.001 volt resolution.

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals on the 945.
2. Connect the voltage/current source to Terminal #1 and #3 on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press the MODE key until **OU** is displayed.
4. Press AUTO/MAN twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **OU** parameter, set the voltage/current source to 0.000volts. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the **5U** parameter, set the voltage/current source to 5.000 volts. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations. Press AUTO/MAN twice to exit the MANUAL mode. To conclude the 0-5 Volt calibration, advance the MODE key to the next prompt or exit the CAL menu.

NOTE

Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Tables, Pages 18 and 20.

4-20mA Input Field Calibration Procedure

Equipment Required:

- Precision current source 0-20mA minimum range with 0.01 mA resolution.

Setup And Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals on the Series 945. Jumper for correct line voltage. See Chapter 2.
2. Connect the voltage/current source to Terminal #1 and #3. Jumper Terminal #2 to #3 on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press the MODE key until **4A** is displayed.
4. Press the AUTO/MAN key twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **4A** parameter, set the mA source to 4.00mA. Allow at least 10 seconds to stabilize. Press the MODE key.
6. At the **20A** parameter, set the voltage/current source to 20.00mA. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations. Press AUTO/MAN twice to exit the MANUAL mode. To conclude, advance the MODE key to the next prompt or exit the CAL menu.

IMPORTANT:

When the MANUAL LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next prompt before changing the calibration equipment.

0 - 5 Volt Retransmit Field Calibration Procedure

Equipment Required:

- 20KΩ, 1/4 watt, 10% resistor.
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 945.
2. Connect the multimeter across the 20KΩ resistor to Terminal #25 Positive and #24 Negative on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. **After warm-up** put the unit in the CAL menu. See Page 29. Press MODE until the **O4LO** prompt is displayed.
4. Press the AUTO/MAN key twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **O4LO** parameter, the multimeter should read approximately 0.00V. Allow at least 10 seconds to stabilize.
6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 0.0 volts. Press the MODE key.
7. At **O4HI**, the multimeter should read approximately 5.00V. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations.
8. Use the AUTO/MAN key twice to exit the MANUAL mode. To conclude the 0-5 volt output calibration, advance the MODE key to the next prompt or exit the CAL menu.

NOTE:

Before calibration on an installed control, make sure all data and parameters are documented. See Setup and Operation Tables, Pages 18 and 20.

IMPORTANT:

When the MANUAL LED is ON the unit is automatically calibrating. Your sequence is VERY important. Always move to the next prompt before changing the calibration equipment.

4-20mA Retransmit Field Calibration Procedure

Equipment Required:

- 470Ω, 1/2 watt 10% resistor.
- 4 1/2 digit Digital Multimeter.

Setup and Calibration

1. Connect the AC line voltage L1, L2, and ground to the proper terminals of the 945.
2. Connect the multimeter in series with the 470Ω resistor to Terminal #25 Positive and #24 Negative on the Series 945 terminal strip. Use regular 20 - 24 gauge wire.
3. Apply power to the unit and allow it to warm up for 15 minutes. After **warm-up** put the unit in the CAL menu. See Page 29. Press MODE until the **O4LO** prompt is displayed.
4. Press the AUTO/MAN key twice to enter the MANUAL mode. The unit is calibrating when the MANUAL LED is ON. Make sure the unit is in the MANUAL mode **only** when you are in the correct parameters. See Figure 40.
5. At the **O4LO** parameter, the multimeter should read approximately 4mA. Allow at least 10 seconds to stabilize.
6. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 4.00mA. Press the MODE key.
7. At **O4HI**, the multimeter should read approximately 20mA. Allow at least 10 seconds to stabilize. The unit leaves the CAL mode if 1 minute passes between key activations.
8. Use the UP/DOWN keys (reverse acting) to adjust the reading on the multimeter for 20.00mA.
9. Press AUTO/MAN twice to exit the MANUAL mode. To conclude, advance the MODE key to the next prompt or exit the CAL menu.

Alarm: A condition, generated by a controller, indicating that the process has exceeded or dropped below a predetermined alarm set point.

Alarm Silence: Disables the alarm relay output.

Anti-reset: Control feature that inhibits automatic reset action outside the proportional band. Also known as "reset windup inhibit."

Automatic prompts: Data entry points where a microprocessor-based control "prompts" or asks the operator/programmer for information input.

Auto-tune: Automatically tunes the Series 945 PID parameters to fit the characteristics of your particular thermal system.

Bumpless transfer: When transferring from auto to manual operation, the control output(s) will not change ("bumpless," smooth transition).

Closed loop: Control system that has a sensing device for process variable feedback.

Cold junction: Point of connection between thermocouple metals and the electronic instrument.

Cold junction compensation: Electronic means to compensate for the ambient temperature at the cold junction.

Cycle time: The time necessary to complete a full ON-through-OFF period in a time proportioning control system.

Data Logging: A convenient replacement for chart recorders. Information is sent from the 945 to a serial printer. Provides a handy reference to review process performance.

Dead band: A temperature band between heating and cooling functions.

Derivative: Anticipatory action that senses the rate of change of the process, and compensates to minimize overshoot and undershoot. Also "rate."

Deviation alarm: An alarm referenced at a fixed number of degrees, plus or minus, from set point.

Default parameters: The parameters permanently stored in memory to provide a data base.

DIN: Deutsche Industrial Norms, a widely-recognized German standard for engineering units.

Droop: Difference in temperature between set point and stabilized process temperature.

Duty cycle: Percentage of "load ON time" relative to total cycle time.

Form A: Single Pole Single Throw relay that only utilizes the N.O. and Common contacts. These contacts close when the relay coil is energized. The contacts open when power is removed from the control.

Form B: Single Pole Single Throw relay that only utilizes the N.C. and Common contacts. These contacts will open when the relay coil is energized. The contacts will close when power is removed from the control.

Form C: Single Pole Double Throw. Utilizes the N.O., N.C. and Common contacts. The user has the option of wiring for a Form A or Form B contact. Refer to Form A & Form B above for more information.

Hysteresis: In ON/OFF control, the temperature change necessary to change the output from full OFF to full ON again.

Hunting: Oscillation or fluctuation of process temperature about the set point.

Input: Process variable information being supplied to the instrument.

Integral: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "reset."

Isolation: Electrical separation of sensor from high voltage circuitry. Allows for application of grounded or ungrounded sensing element.

JIS Japanese Industrial Standards. Also Japanese Industrial Standards Committee (JISC). Establishes standards on equipment and components.

Offset: Adjustment to actual input temperature and to the temperature values the Series 945 uses for display and control.

ON/OFF control: Control of temperature about a set point by turning the output full ON below set point and full OFF above set point in the heat mode.

Open loop: System with no sensory feedback.

Output: Action in response to difference between set point and process variable.

Overshoot: Condition where temperature exceeds set point due to initial power up or process changes.

Parameter: A physical property whose value determines the response of an electronic control to given inputs.

PID control: Proportioning control with auto-reset and rate. Also known as 3 mode control.

Process variable: Thermal system element to be regulated, such as time, temperature, relative humidity, etc.

Proportional band: Span of temperature about the set point where time proportional control action takes place.

Rate: Anticipatory action that senses the rate of change of temperature and compensates to minimize overshoot. Also "derivative."

Rate Band: A thermal control band that defines where the rate (derivative) function begins. A Watlow rate band occurs centered on set point at one or more times the width of the proportional band.

Reset: Control action that automatically eliminates offset, or "droop," between set point and actual process temperature. Also "integral."

RTD: Resistance Temperature Detector. Resistive sensing device displaying resistance versus temperature characteristics. Displays positive temperature coefficient.

Set point: Intended value of the process variable.

Switching sensitivity: In ON/OFF control, the temperature change necessary to change the output from full ON to full OFF.

Thermal system: A regulated environment consisting of a heat source, heat transfer medium, sensing device and a process variable control instrument.

Thermocouple: Temperature sensing device that is constructed of two dissimilar metals wherein a measurable, predictable voltage is generated corresponding to temperature.

Thermocouple break protection: Fail-safe operation that assures output shutdown upon an open thermocouple condition.

Time Proportioning Control: Action which varies the amount of ON time when "close" to the set point, i.e., in the proportional band. This variance is proportional to the difference between the set point and the actual process temperature. In other words, the amount of time the output relay is energized depends on the system temperature.

Warm Start: Start-up condition where all program information is remembered by the instrument's memory back-up protection.

Zero switching: Action that provides output switching only at the zero voltage crossing points of the AC line.

Index

Specifications

Control Mode
- Single or dual set point, non-ramping.
- Single input, dual outputs, dual alarms.
- RS-422A, RS-423A, or EIA-485 data communications.
- Optional retransmit of set point or process variable.
- Control outputs: User selectable as: Heat, Heat/Heat, Heat/Cool, Cool, Cool/Cool, Cool/Heat.
  - Outputs independent, or related via dead band for Heat/Cool.
  - ON/OFF: Determined by the HYSX parameter for Outputs 1 and 2.
  - PID parameters:
    Proportional band: 0 to 999°F/0 to 555°C/0 to 999 U
    Reset: 0.00 to 9.99 repeats per minute.
    Integral: 0 and 00.1 to 99.9 minutes per repeat.
    Rate/Derivative: 0.00 to 9.99 minutes.
    Cycle time: 1 to 60 seconds.
  - Dead band: ±99°F, ±99 units or ±55°C (±9.9°F, ±9.9 units or ±5.5°C for rtd.1 and process units)

Operator Interface
- Membrane front panel.
- Dual, four digit 0.56" (14 mm) LED displays.
- MODE, AUTO/MANUAL, UP, and DOWN keys.

Input
- Thermocouple, RTD, and electrical process input.
- Automatic cold junction compensation for thermocouple.
- RTD input 2 or 3 wire, platinum, 100 ohm @ 0°C software selectable, JIS curve #3916 (0.003916 Ω/Ω/°C) or DIN curve #3850 (0.003850 Ω/Ω/°C).
- Sensor break protection de-energizes control outputs to protect system.
- Grounded or ungrounded sensors.
- °F,°C, or process variable units are user selectable.
- Operating ranges user selectable.

J t/c:	32	to	1382°F	or	0	to 750°C
K t/c:	-328	to	2282°F	or	-200	to 1250°C
T t/c:	-328	to	662°F	or	-200	to 350°C
N t/c:	32	to	2282°F	or	0	to 1250°C
C t/c:	797	to	4200°F	or	425	to 2315 °C
PT 2 (Platinel 2)	32	to	2543°F	or	0	to 1395°C
R t/c:	32	to	2642°F	or	0	to 1450°C
S t/c:	32	to	2642°F	or	0	to 1450°C
B t/c:	1598	to	3092°F	or	870	to 1700°C
1° RTD:	-328	to	1112°F	or	-200	to 600°C
0.1° RTD:	-99.9	to	392.0°F	or	-99.9	to 200.0°C
0-5VDC:	-500 to 3500 units					
4-20mA:	-500 to 3500 units					

Primary Output (Heating or Cooling)
- Solid state relay, 0.5A @ 24VAC min., 264VAC max. opto-isolated, zero cross switching. Off state impedance is 20KΩ minimum for 952A-XBXX-X000 units, and 31MΩ for 945A-XKXX-X000 units.
- Electromechanical relay, Form C, 6A @ 120/240VAC, 6A @ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ minimum.
- Switched DC (Open collector), 500Ω min. load resistance, 1KΩ load,9mA min., 22mA max., non-isolated.
- 4-20mA reverse or direct acting into a 600Ω maximum load impedance,non-isolated.
- 0-5 VDC reverse or direct into a 10KΩ minimum load impedance, non-isolated.

Secondary Output (Heat, Cool or None)
- Solid state relay, Form A, 0.5A @ 24VAC min., 264VAC maximum, opto-isolated, zero cross switching. Off state impedance is 20KΩ minimum for 945A-XBXX-X000 units, and 31MΩ for 945A-XKXX-X000 units.
- Electromechanical relay, Form A, 6A @ 120/240VAC, 6A @ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ min.
- Switched DC (Open collector), 500Ω min. load resistance, 1KΩ load, 9mA min., 22mA max., non-isolated.

Alarms
- Electromechanical relay, Form A (N.O.) or B (N.C.), 6A @ 120/240VAC, 6A@ 28VDC, 1/8 hp. @ 120VAC, 125VA @ 120VAC. Off state impedance is 20KΩ min.
- Latching or non-latching.
- Process or deviation.
- Separate high and low values.
- Alarm silencing (inhibit) on power up for Alarm 1.

Retransmit Output
- 4-20mA into a 600Ω maximum load, non-isolated.
- 0-5VDC into a 10KΩ minimum load, non-isolated.
- Retransmit of process or set point. User selectable range.

Accuracy
- Calibration Accuracy & Sensor Conformity: ± 0.1% of span, ± 1LSD, 77°F ± 5°F(25°C ±3°C) ambient & rated line voltage ±10%.
- Accuracy Span: 1000°F or 540°C minimum.
- Temperature Stability: 0.1°F/°F (0.1°C/°C) change in ambient.
- Voltage Stability: ± 0.01% of span / % of rated line voltage.

Communications
- Serial data communications.
- RS-422A or RS-423A (RS-232C compatible) or EIA-485.
- ANSI X3.28 protocol, or XON/XOFF protocol.
- Isolated.
- Data logging.
- #6 compression type screw terminals.

Agency Approvals
- UL recognized, File #E43684, UL873.
- CSA recognized, File # LR30586.

Terminals
- #6 compression type screw terminals.

Power
- 120/240VAC +10%, -15%, 50/60Hz, ± 5%.
- 16VA maximum.
- Data retention upon power failure via nonvolatile memory.

Operating Environment
- 32 to 149°F/0 to 65°C.
- 0 to 90% RH, non-condensing.

Dimensions

• Height:	3.8 in	97 mm
• Width:	3.8 in	97 mm
• Overall depth:	7.0 in	178 mm
• Behind panel depth:	6.0 in	153 mm
• Weight:	2.5 lb max.	0.4 kg

Model No.

9 4 5 A – _ _ _ _ – 0 0 0

Series
945 = 1/4 DIN, single input, dual output dual alarms, dual digital displays.

Inputs Type
- 1 = Type J, K, T, N, C, PT 2 thermocouple
- 2 = Type J, K, T, N, C, PT 2 thermocouple, RTD 1°, 4-20mA, 0-5VDC
- 3 = Type J, K, T, N, C, PT 2 thermocouple, RTD 0.1°, 4-20mA, 0-5VDC
- 4 = Type R, S, B thermocouple

#1 Output Type
- B = Solid State Relay, Form A, 0.5A
- C = Switched DC, (Open Collector), non-isolated
- D = Mechanical Relay, Form C, 6A
- F = Process 4-20mA, non-isolated
- H = Process 0-5VDC, non-isolated
- K = Solid State Relay without contact suppression, Form A, 0.5A

#2 Output Type
- A = None
- B = Solid State Relay, Form A, 0.5A
- C = Switched DC, (Open Collector), non-isolated
- D = Mechanical Relay, Form A, 6A
- K = Solid State Relay without contact suppression, Form A, 0.5A

Alarms
- 0 = None
- 1 = Single, Mechanical Relay, 6A, Form A or B
- 2 = Dual, Mechanical Relay, 6A, Form A or B
- 3 = Single, Mechanical Relay, 6A/0-5VDC Retransmit
- 4 = Single, Mechanical Relay, 6A/4-20mA Retransmit
- 5 = No Alarm Output/0-5VDC Retransmit
- 6 = No Alarm Output/ 4-20mA Retransmit

Communications
- A = None
- B = Isolated RS-423/RS-422
- D = Isolated EIA-485

Returns

1. Call Watlow Customer Service, 507/454-5300, for a Return Material Authorization (RMA) number before returning any item for repair. We need this information:
   - Ship to address
   - Bill to address
   - Contact name
   - Phone number
   - Ship via
   - Your P.O. number
   - Symptoms and/or special instructions
   - Name and phone number of person returning the material.
2. Prior approval and an RMA number, from the Customer Service Department, is needed when returning any unused product for credit. Make sure the RMA number is on the outside of the carton, and on all paperwork returned. Ship on a Freight Prepaid basis.
3. After we receive your return, we will examine it and determine the cause for your action.
4. In cases of manufacturing defect, we will enter a repair order, replacement order, or issue credit for material. A 20 percent restocking charge is applied for all returned stock controls and accessories.
5. If the unit is unrepairable, it will be returned to you with a letter of explanation. Repair costs will not exceed 50 percent of the original cost.

Warranty

The Watlow Series 945 is warranted to be free of defects in material and workmanship for 36 months after delivery to the first purchaser for use, providing that the units have not been misapplied.

Since Watlow has no control over their use, and sometimes misuse, we cannot guarantee against failure. Watlow's obligations hereunder, at Watlow's option, are limited to replacement, repair or refund of purchase price, and parts which upon examination prove to be defective within the warranty period specified. This warranty does not apply to damage resulting from transportation, alteration, misuse, or abuse.

APPENDIX C

Document #: 80276
Revision: _____
Date Released: 4-28-92

UNIBED SORBENT SIZING CALCULATIONS

OF THE POSTTREATMENT UNIBED FOR THE CATALYTIC OXIDATION

SYSTEM WITH A DIRECT HUMIDITY CONDENSATE FEED

FOR THE

NASA-MSFC PHASE II SBIR:

CATALYTIC METHODS USING MOLECULAR OXYGEN FOR

TREATMENT OF PMMS AND ECLSS WASTE STREAMS

Prepared By: _____

Approved By: _____ **Date:** 4-28-92

Approved By: _____ **Date:** 4-28-92

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LIST OF FIGURES & TABLES

1.0 INTRODUCTION

This document presents the Posttreatment Unibed design which will be used to treat the effluent from a catalytic oxidation system whose influent is ersatz humidity condensate. The humidity condensate's composition is shown in Table 1. After passage through the catalytic oxidation system most of the inorganic constituents remain unchanged while the organic species are oxidized to their component gases of which carbon dioxide and water vapor predominate. Organic sulphur is oxidized to sulfate anions. Organic nitrogen is either oxidized to nitrogen gas or converted to ammonium ions depending on the solution's contact time. This sub-bed is designed to remove these various inorganic species. In addition, oxidized organic species which are present at very low levels will be removed. The effluent from this bed should meet or surpass the NASA potable water requirements shown in Table 2. This bed should be installed down stream of the catalytic oxidation system. (see Figure 1)

1.1 Applicable Document

1.1.1 SBIR Phase II Contract NAS8-38490

1.2 Applicable Drawings

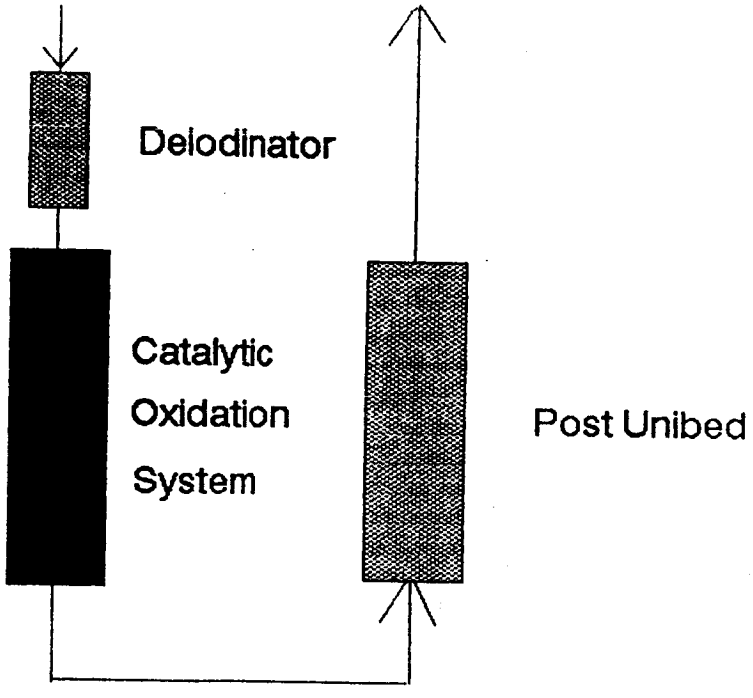
1.2.1 Umpqua Research: URC DWG 90207

1.3 General Approach

The design is based on (1) isotherm data from shaker table and small column single contaminant, single media tests performed at UMPQUA under the following NASA contracts: NAS9-17073, NAS9-17464, NAS9-1753, and NAS9-17611 and (2) manufacturer's stated ion exchange capacity.

FIGURE 1

BED LOCATION



2.0 DESIGN REQUIREMENTS

2.1 Configuration

2.1.1 One 15 in long, 2 in diameter stainless steel tube with inner teflon coating and 1/8 " pipe thread elbows at the inlet and outlet.

2.2 Life at Design Conditions

2.2.1 Throughput: 720 L

2.2.2 Time: 50 days

2.3 Inlet Solution

2.3.1 Efffluent from Catalytic Oxidation Reactor (Table 3)

2.4 Flow

2.4.1 Flow Rate: 10 mL/min ≈ 0.6 L/hr (1.32 lb/hr)

2.4.2 Daily Operating Time: 24 hr/day

2.4.3 1-Day Throughput: 14.4 L

2.5 Temperature

2.5.1 Operating Range: 68 - 77 F

2.6 Pressure

2.6.1 Maximum Operating Pressure (MOP): 40 psig

2.6.2 Proof Pressure: 60 ± 5 psig

2.7 Pressure Drop

2.7.1 Maximum Allowable Pressure Drop: 5 psig

2.8 Iodine Output

2.7.1 Range: 0.5 - 4.0 ppm

2.9 Outlet Quality

2.9.1 Water Quality Requirements: See Table 2. (NOTE: This standard applies prior to iodination.)

3.0 DESIGN DATA

The design data were developed by UMPQUA under contract to NASA-JSC for the ion exchange and MCV media (see paragraph 1.3 for applicable contract numbers).

3.1 Sorbent Selection

The best performing media have been selected for each sub-bed, based on single adsorbent-single contaminant/shaker table and single adsorbent-single contaminant/dynamic column tests run previously by UMPQUA. The selected adsorbents are listed in Table 3.

3.2 Adsorption Equilibrium Data

Table 3 also contains ion exchange loadings (equilibrium data) necessary for the design of the sorption sub-beds. These data are from UMPQUA small-column tests and are lower than the manufacturer's published values.

4.0 UNIBED DESIGN

4.1 Unibed Dimensions

The unibed consists of a single 2 in x 15 in long stainless steel housing containing nominally, 661 cc of media. The total bed length is 12.84 in. A sub-bed volume of 60 cc provides the minimum bed length to diameter ratio necessary to insure proper sub-bed performance. The remaining volume is occupied by lip seals, an internal spring and the end caps.

Table 1

ERSATZ HUMIDITY CONDENSATE

Organics

	mg/liter	TOC (mg/liter)
Caprylic Acid	0.537	0.358
Dibutylamine	7.28	5.412
Dimethyl Phthalate	0.548	0.339
Ethanol	14.00	7.300
Formic Acid	1.65	0.431
Isopropanol	0.87	0.522
Lactic Acid	0.93	0.372
Methanol	1.54	0.577
Propanoic Acid	0.871	0.424
Thiourea	14.56	2.298
	42.79 mg/liter	18.03 mg/liter

Inorganics

Ammonium Hydroxide	36.3
Ammonium Phosphate	0.53
Ammonium Sulphate	0.25
Calcium Chloride	0.15
Sodium Chloride	0.36
Sodium Fluoride	0.49
Sodium Nitrate	0.36
	38.44 mg/liter

TABLE 2. WATER QUALITY REQUIREMENTS
(Maximum Contaminant Levels)

QUALITY PARAMETERS	POTABLE WATER
PHYSICAL PARAMETERS	
Total Solids (mg/l)	100
Color, True (Pt/Co units)	15
Taste (TTN)	3
Odor (TON)	3
Particulates (max size - microns)	40
pH	6.0-8.5
Turbidity (NTU)	1
Dissolved gas (free @ 37 C)	Note 1
Free gas (@ STP)	Note 1
INORGANIC CONSTITUENTS (mg/l) (See Note 2)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chloride	200
Chromium	0.05
Copper	1.0
Iodine (Total-includes organic iodine)	15
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO_3-N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0

TABLE 2. WATER QUALITY REQUIREMENTS (Continued)
(Maximum Contaminant Levels)

QUALITY PARAMETERS	POTABLE WATER
ASTHETICS (mg/l)	
Cations	30
Anions	30
CO_2	15
MICROBIAL	
Bacteria (CFU/100 ml)	
Total Count	1
Anaerobes	1
Coliform	1
Virus (PFU/100 ml)	1
Yeast & Mold (CFU/100 ml)	1
RADIOACTIVE CONSTITUENTS (pCi/l)	Note 3
ORGANIC PARAMETERS (µg/l) (See Note 2)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Phenols	1
Total Alcohols	500
Total Organic Carbon (TOC)	500
Uncharacterized TOC (UTOC)(See Note 4)	100
ORGANIC CONSTITUENTS (mg/l) (See Note 2)	

Note 1: No detectable gas using a volumetric gas vs fluid measurement system. Excludes CO_2 used for aesthetic purposes.

Note 2: Each parameter/constituent MCL must be considered individually and independently of others.

Note 3: The maximum contaminant levels for radioactive constituents in potable and personal hygiene water shall conform to Nuclear Regulatory Commission (NRC) regulations (10CFR20, et al.). These maximum contaminant levels are listed in the Federal Register, Vol. 51, No. 6, 1986, Appendix B, as Table 2 (Reference Level Concentrations) Column 2 (Water). Control/contaminant/monitoring of radioactive constituents used on SSF shall be the responsibility of the user. Prior to the introduction of any radioactive constituents on SSF, approval shall be obtained from the Radiation Constraints Panel (RCP). The RCP will approve or disapprove proposed monitoring and decontamination procedures on a case-by-case basis.

Note 4: UTOC equals TOC minus the sum of analyzed organic constituents expressed in equivalent TOC.

TABLE 3. POSTTREATMENT UNIBED (DIRECT HUMIDITY CONDENSATE INFLUENT)

CONTAMINANT	CONCENTRATION (meq/liter)	MEDIA	MFG's' CAPACITY (meq/cm^3)	URC DESIGN CAPACITY (mg/cm^3)	SWELLING %
Ammoniuim	0.17	IRN 77	1.7	30.7	- 5
		IRN 150	0.8	14.4	-20
Calcium	0.005	IRN 77	1.7	34.1	- 5
		IRN 150	0.8	16.0	-20
Sodium	0.002	IRN 77	1.7	39.1	-5
		IRN 150	0.8	18.4	-20
Sulphate	0.39	IRN 78	1.2	57.6	-30
		IRN 150	0.8	38.4	-20
Fluoride	0.012	IRN 78	1.2	22.8	-30
		IRN 150	0.8	15.2	-20
Chloride	0.009	IRN 78	1.2	42.5	-30
		IRN 150	0.8	28.4	-20
Hydrogen Phosphate	0.008	IRN 78	1.2	57.6	-30
		IRN 150	0.8	38.4	-20
Nitrate	0.0042	IRN 78	1.2	74.4	-30
		IRN 150	0.8	49.6	-20
Organic Acids	1.39×10^{-5}	IRA 68	1.6	4.9	+20

TABLE 4. POSTTREATMENT UNIBED MEDIA CONFIGURATION

Direction	Sorbent	Ref. Para	Volume (cc)	Function
↓	MVC-RT	4.2.1	60	Microbial Control
	IRN-78	4.2.2	167	Remove Inorganic Anions
	IRN-150	4.2.3	224	Remove Inorganic Cations Remove Inorganic Anion
	IRA-68	4.2.4	150	Remove Organic Acids
	MCV-RT	4.3.1	60	Microbial Control

4.2 Unibed Configuration and Sub-bed Sizing

The configuration of the alcohol oxidase unibed is shown in Table 4. The initial MCV^{RT} resin sub-bed maintains the sterile integrity of the unibed. The second sub-bed containing IRN-78 removes anions such as sulfate, hydrogen phosphate, chloride, fluoride, and nitrate. The third sub-bed contains IRN-150, a mixed exchange resin, which removes both cations and the anions previously mentioned. The cations removed include ammonium, calcium, and sodium. The next sub-bed consists of IRA-68, a weak base exchange resin, which removes oxidized organic species such as organic acids. The final MCV^{RT} resin sub-bed imparts iodine into the effluent for microbial control. The sizing rationale for each sub-bed is represented in the following paragraphs.

4.2.1 MCV^{RT}

MCV^{RT} resin is required at the entrance for microbial control within the bed. This resin puts out 0.5 to 6.0 ppm of I_2 with a capacity of 50 liters/cm^3 of media.

LIFE: 60 cm^3 x 50 L/cm^3 ÷ 14.4 L/day = 208 days.

4.2.2 IRN 78

The anions to be removed include sulphate, fluoride, chloride, hydrogen phosphate, and nitrate. Their concentrations are given by:

$SO_4^{=}$ = 0.39 meg/L, F^- = 0.012 meg/L,

Cl^- = 0.0089 meg/cm^3,

$HPO_4^{=}$ = 0.0080 meg/cm^3, and NO_3^- = 0.0042 meg/cm^3.

The 167 cm^3 sub-bed of IRN-78 will hold 1.2 meg/cm^3.

Total Sorption Capacity:

167 cm^3 x 1.2 meg/cm^3 = 200.4 meg

Total Sorption Capacity:

167 cm^3 x 1.2 meq/cm^3 = 200.4 meq

Throughput Capacity: 200.4 meq ÷ 0.4246 meq/L = 474 L

Life: 472 L ÷ 14.4 L/day = 33 days

4.2.3 IRN-150

The anions to be removed include those listed above. The cations to be removed include ammonium, calcium, and sodium. Their concentrations are given by:

NH_4^+ = 0.17 meq/L, Ca^{2+} = 0.0054 meq/L,

and Na^+ = 0.022 meq/L.

The 224 cm^3 bed of IRN-150 will remove a 0.8 meq/cm^3 of anions and 0.8 meq/cm^3 of cations.

Total Anionic Sorption Capacity:

224 cm^3 x 0.8 meq/cm^3 = 179.2 meq

Total Cationic Sorption Capacity:

224 cm^3 x 0.8 meq/cm^3 = 179.2 meq

Anionic Throughput Capacity:

179.2 meq ÷ 0.4246 meq/L = 422 L

Cationic Throughput Capacity:

179.2 meq ÷ 0.1939 meq/L = 924 L

Anionic Life: 29 days

Cationic Life: 64 days

4.2.4 IRA-68

The organics which remain in the catalytic oxidation system's effluent are highly oxidized, low molecular weight species which are likely to be organic acids. Their concentrations are low and variable. Taking the average concentration to correspond to a total organic carbon level of 0.5 mg/liter, the potable

water limit, and the average composition to be approximated by propanoic acid, then the total concentration will be 1.03 mg/liter.

The 150 cm^3 bed of IRA-68 will remove 4.9 mg/cm^3 of the organic acid.

Total Sorption Capacity: 150 cm^3 x 4.9 mg/cm^3 = 735 mg

Throughput Capacity: 735 mg ÷ 1.028 mg/L = 715 L

Life: 715 L ÷ 14.4 L/day = 50 days

4.2.5 MCV-RT

Life: 60 cm^3 x 50 L/cm^3 ÷ 14.4 L/day = 208 days

4.2.6 Sizing Discussion

The design summarized in Table 4 was obtained within the dimension restraints given in Paragraph 4.1. The capacity is limited by the overall bed size. The limiting factor is the bed life of the IRA-68 sub-bed which is 50 days. This bed life is a worst case scenario and actual bed life should be longer.

4.3 Pressure Drop

Previous testing developed a pressure drop equation.

$$\delta P = 0.4\ WL\ \mu/D^2$$

where:

δP = Pressure drop, psi

W = flow rate, lb/min

L = bed length, in

D = bed diameter, in

μ = viscosity, centipoise

For the post bed:

$W = 1.32$ lb/hr = 0.022 lb/min

$L = 12.5$ in

$D = 2$ in

$\mu = 1$ centipoise

$\delta P = 0.4\ (0.022)(12.5)(1)/(2)^2 = 0.03$ psi

Specified max $\delta P = 5.0$ psi

4.4 Summary of Unibed Design Values

A summary of the design values for the beds is given in Table 5.

TABLE 5. SUMMARY OF POST UNIBED DESIGN VALUES

Parameter	Value
URC Drawing Number	90207
Nominal ID	2 in
Water System	Potable
Flow Rate	1.32 lb/hr (0.6 L/hr)
Daily Operating Time	24 hr/day
Thruput, 1 day	14.4 L
Total Media Volume	661 cc
Cross Sectional Area	20.3 cm^2
Total Length of Media (Installed)	12.84 in
Face Velocity	0.493 cm/min
Empty Bed Contact Time	66.1 min
Life (limited by IRA-68)	720 L, 50 days

APPENDIX I

MEDIA INFROMATION

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRN-78

ION EXCHANGE RESIN

Amberlite IRN-78 is a strongly basic gel type polystyrene anion exchange resin supplied in the hydroxide form. This resin is Nuclear Grade and processed to the highest purity standards required for treating water in the nuclear power industry. Amberlite IRN-78 contains a minimum of 95% of the exchange sites in the hydroxide form and a maximum of 0.10% in either the chloride or sulfate form. This is achieved by a patented Rohm and Haas low chloride regeneration process.

The manufacturing process for this resin is controlled to keep inorganic impurities, including chloride and sulfate, at the lowest possible levels. These two impurities are known to cause corrosion in the primary circuit and must be kept to a minimum. Special treatment procedures are also practiced to remove traces of soluble organic compounds. These high standards of resin purity will help to keep the nuclear systems free of contaminants and deposits and prevent increases in radioactivity levels due to activation of impurities as the water circulates through the reactor core.

IMPORTANT FEATURES OF AMBERLITE IRN-78 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-78 resin exhibits a minimum of 1.1 meq/ml.

EXCEPTIONAL PURITY: Amberlite IRN-78 resin is manufactured to demanding purity specifications which assure a minimum of ionic and nonionic contamination.

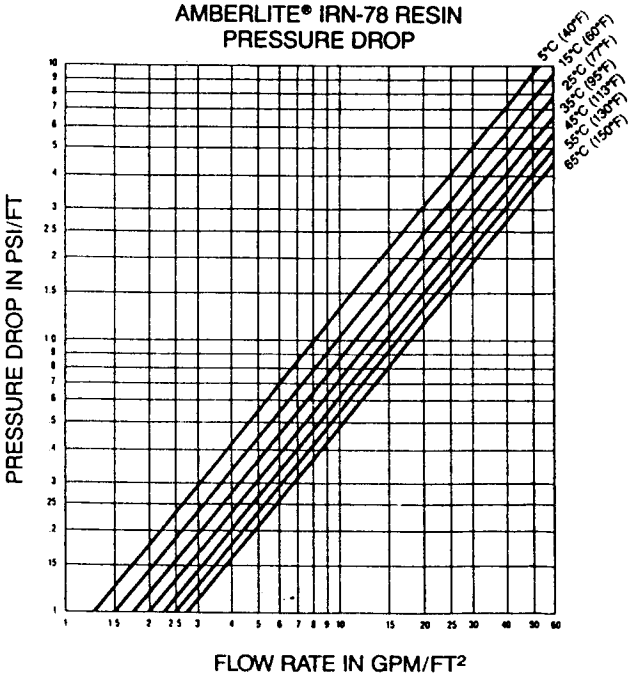
GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-78 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

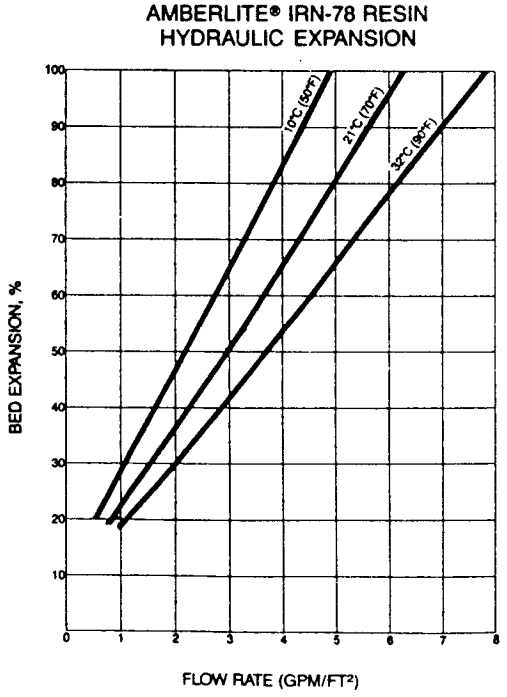
HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-78 resin in normal downflow operation at various temperatures and flow rates is shown in the graphs below (data based on backwashed and classified resin bed).

RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO_2 pickup and subsequent loss of capacity of the anion resin. If the resin requires backwashing the bed should be expanded a minimum of 50%.



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45
PSI/ft to MH_2O/M resin = PSI/ft x 2.30



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45

RECOMMENDED CONDITIONS OF OPERATION

BED DEPTH:	24" minimum (0.61 m)
TEMPERATURE:	140°F maximum (60°C)
SERVICE FLOW RATE:	1-5 gpm/ft³ (8.0 to 40.1 l/hr/l)

CHEMICAL CHARACTERISTICS

IONIC FORM:	Hydroxide
TOTAL EXCHANGE CAPACITY:	1.1 meq/ml minimum
MOISTURE CONTENT:	60% maximum
IONIC CONTENT:	
Equivalent % OH minimum	95.0
Equivalent % Cl maximum	0.10
Equivalent % CO_3 maximum	5.0
Equivalent % SO_4 maximum	0.10
METALS CONTENT:	
Sodium (ppm dry resin) maximum	50.0
Iron (ppm dry resin) maximum	50.0
Copper (ppm dry resin) maximum	10.0
Heavy Metals as Pb (ppm dry resin) maximum	10.0
Aluminum (ppm dry resin) maximum	50.0
Calcium (ppm dry resin) maximum	50.0
Magnesium (ppm dry resin) maximum	50.0

PHYSICAL CHARACTERISTICS

SHAPE:	Spherical beads
SHIPPING WEIGHT:	43 lbs/ft³ (688 g/l)
PARTICLE SIZE (U.S. MESH):	
Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5
CHATILLON:	
Avg., gm/bead	350 minimum
% 200 gm/bead	95 minimum
SOLUBILITY:	0.10% maximum
PERFECT BEADS:	95% minimum

APPLICATIONS

PRIMARY WATER TREATMENT: Amberlite IRN-78 resin is very effective in removing I^{131} I^{133} and trace Cl^- contamination from reactor coolant streams. It is also useful in controlling the boron level in the primary system.

RAD WASTE TREATMENT: Amberlite IRN-78 resin is very effective in removing radioactive anions such as Iodine 131 and 133 from waste streams.

DECONTAMINATION: Amberlite IRN-78 resin removes anionic radioactive material from spent decontaminating solutions.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-78 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

January 1986 Printed in U.S.A.

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
ID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRA-68

Amberlite IRA-68 is a gel type, weakly basic anion exchange resin possessing tertiary amine functionality in a crosslinked acrylic matrix. In addition to exhibiting a high exchange capacity, this resin has good chemical and thermal stability and is especially suited to the adsorption and desorption of organic materials from solution. Amberlite IRA-68 is also well suited for applications in the pharmaceutical, chemical and food processing industries for the neutralization of strong acids and other special processes.

IMPORTANT FEATURES OF AMBERLITE IRA-68

HIGH CAPACITY AND LOW COST REGENERATION—Amberlite IRA-68 has an operating acid removal exchange capacity of 29 kgrs/ft³ (66.4 g/l as $CaCO_3$) of resin. Regeneration is accomplished using 110-120% of the quantity of base chemically equivalent to the operating capacity. Thus, regenerant costs are significantly lower than for strongly basic resins and waste problems are held at a minimum.

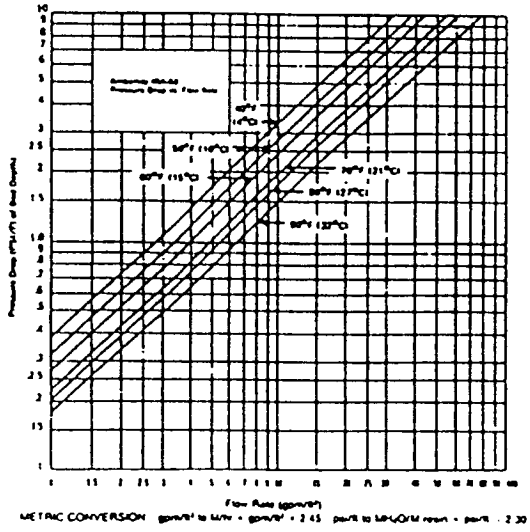
RESISTANCE TO ORGANIC FOULING—Amberlite IRA-68 is synthesized with an open structure which permits the effective adsorption and desorption of large organic molecules. Because of this open structure, organic materials are readily eluted from Amberlite IRA-68 resulting in no capacity loss due to organic fouling.

CHEMICAL FORM—Amberlite IRA-68 is shipped in the fully regenerated free-base form and can be utilized immediately for acid removal.

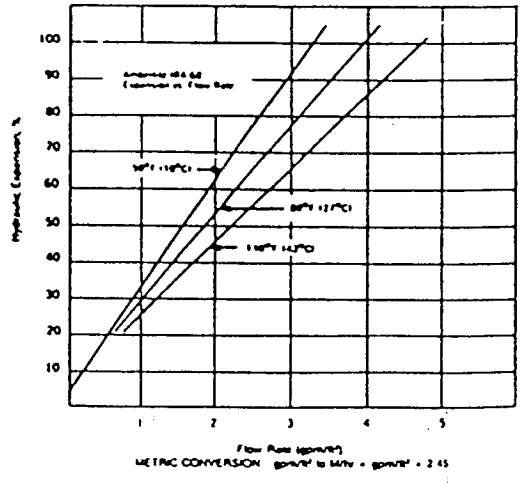
INSOLUBLE IN ALL COMMON SOLVENTS.

HYDRAULIC CHARACTERISTICS

PRESSURE DROP—The curves show the expected pressure drop per foot of bed depth in normal downflow operation at various temperatures as a function of flow rate.



BACKWASH CHARACTERISTICS—After each operational cycle Amberlite IRA-68 should be backwashed for approximately ten minutes to re-classify the resin particles and purge the bed of any insoluble material which may have collected on top of the resin. The resin bed should be expanded a minimum to 50% during backwash.



PHYSICAL CHARACTERISTICS

PHYSICAL FORM—Uniform, spherical particles shipped in moist, fully regenerated condition.

DENSITY—41 to 47 lbs/ft³ (656 to 752 g/l)

SHIPPING WEIGHT—45 lbs/ft³ (720 g/l)

MOISTURE CONTENT—60% as shipped *

SCREEN GRADING (WET)—16 to 50 mesh (U.S. Standard Screen)

EFFECTIVE SIZE—0.45 mm.*

FINES CONTENT—3% maximum

SWELLING—20%* upon complete conversion of the resin from the free base to the chloride form.

*Approximate

SUGGESTED OPERATING CONDITIONS

pH Limitation — 0 to 7
Maximum Temperature — 140°F (60°C)
Minimum Bed Depth — 24 inches (0.61 m)
Backwash Flow Rate — See detailed information
Regenerant Concentration* — 4%
Regenerant Flow Rate — 0.5 to 1.0 gpm/ft³ (4.0 to 8.0 l/hr/l)
Regeneration Level — See detailed information
Rinse Flow Rate — 0.5 gpm/ft³ (4.0 l/hr/l) initially, to displace regenerant then 1.5 gpm/ft³ (12.0 l/hr/l)
Rinse Water Requirements — 50 to 75 gal/ft³ (6.7 to 10.1 l/l)
Service Flow Rate — 1 to 3 gpm/ft³ (8.0 to 24.1 l/hr/l)
Exchange Capacity — See detailed information
*See Safe Handling Information section

REGENERATION LEVEL AND CAPACITY

A minimum acid removal operating capacity of 28 kgrs. (as $CaCo_3/ft^3$) (64 g/l) of resin may be expected using the following amounts of regenerants:

3.7 lbs of NaOH/ft³ (59.2 g/l) or
3.2 lbs of NH_4OH/ft^3 (51.2 g/l) or
4.9 lbs of Na_2Co_3/ft^3 (78.4 g/l)

APPLICATIONS

DEIONIZATION — The marked worldwide increase in the use of acrylic anion exchange resins is illustrated by the increased utilization of Amberlite IRA-458 as the strongly basic anion exchange component of many deionization systems. Amberlite IRA-458 is installed when high capacity, excellent organic fouling resistance, and good physical stability are required. Where plant design, however, dictates the use of a weakly basic anion exchange resin with properties comparable to those of Amberlite IRA-458, Amberlite IRA-68 is the prime choice.

Amberlite IRA-68 is a gelular acryic weakly basic anion exchange resin with tertiary amine functionality. The acrylic matrix of Amberlite IRA-68 is hydrophilic making it similar to that of Amberlite IRA-458. When compared with gelular polystyrene or epoxy-amine type resins, the acrylic matrix of Amberlite IRA-68 shows superior kinetic behavior particularly in regeneration elution of organics. This superior organic fouling resistance places Amberlite IRA-68 in the same class as *macroreticular* styrene weakly base anion exchange resins.

The flexible nature of the gelular acrylic matrix imparts excellent physical stability with regard to mechanical attrition, and osmotic shock. This, again, is normally attributed to a macroreticular structure.

In contrast to most weakly basic anion exchange resins, the working capacity of Amberlite IRA-68 is independent of service flow rate (1.0 to 5.0 gpm/ft³ [8.0 to 40.1 l/hr/l]), temperature (40°–70°F [4 to 21°C]), and only slightly affected by influent water analysis changes. A base working capacity of 29.0 kgr/ft³ (66.4 g/l) can be expected under normal operating conditions.

The weakly basic anion exchange resin Amberlite IRA-68 incorporates the high working capacity of gel styrene and gel epoxy-amine weakly basic anion exchange resins, without the latter resins' inherent physical weaknesses and organic fouling tendencies. At the same time, it also incorporates the superior physical stability and organic fouling resistance associated with macroreticular weakly basic anion exchange resins, while avoiding the lower working capacities normally associated with macroreticular structure.

ACID MINE DRAINAGE — A modification of the DESAL Process for the treatment of acid mine drainage water has been developed in the Rohm and Haas laboratories. This process, utilizing Amberlite IRA-68 operating in the bicarbonate cycle, converts metallic sulfates, the principal anionic constituents of AMD waters, into soluble bicarbonates which when aerated precipitate as insoluble hydrous oxides. The resulting effluent water will contain calcium and magnesium hardness, which if desired, can be softened using a cold lime softening treatment.

DEIONIZATION AND ORGANIC SCAVENGING — Amberlite IRA-68 is particularly suited for the removal of strong acids and the deionization of process liquors. This resin should be considered for use in the deionization of water and special applications where high molecular weight materials are to be removed from solution.

DIASHING AND DECOLORING CORN SUGAR — When properly pretreated Amberlite IRA-68 is cleared for use in food processing under FDA Food Additive Regulation 21CFR-173.25. According to this regulation the food or aqueous flow must be maintained at 50°C or below, and the flow through the resin must be less than 0.5 gpm/ft³ (4.0 l/hr/l).

SAFE HANDLING INFORMATION — A Material Safety Data Sheet is available for Amberlite IRA-68. To obtain a copy contact your Rohm and Haas representative.

Caution: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

IE-120-67/80 June 1982 Printed in U.S.A.

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRN-150

ION EXCHANGE RESIN

Amberlite IRN-150 is a mixture of gelular, polystyrene cation and anion exchange resins. Amberlite IRN-150 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation (Amberlite IRN-77) and the strongly basic anion (Amberlite IRN-78) exchange resins. It is supplied in the hydrogen/hydroxide form as clear, amber colored spherical particles virtually perfect in bead appearance. Amberlite IRN-150 resin is designed for use in industrial water treatment applications, particularly in once through applications such as primary water chemistry control in nuclear power operations. This resin combines the properties of high capacity and excellent resistance to bead fracture from attrition or osmotic shock.

Amberlite IRN-150 resin is designated as a Nuclear Grade resin and is manufactured using special processing procedures. These procedures, combined with a patented Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry. Amberlite IRN-150 resin is recommended in any non-regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non-ionic contamination.

IMPORTANT FEATURES OF AMBERLITE IRN-150 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-150 resin will exhibit a nominal operating capacity of 12 kg/ft³ (0.55 meq/ml).

EXCEPTIONAL PURITY: Amberlite IRN-150 resin is manufactured to demanding purity specifications which assure a minimum of ionic and non-ionic contamination.

GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-150 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

RECOMMENDED CONDITIONS OF OPERATION

The recommended conditions for operation of Amberlite IRN-150 resin are listed below.

BED DEPTH:	24" minimum (0.61 m)
SERVICE FLOW RATE:	2–5 gpm/ft³ (16 to 40.1 l/hr/l)

PHYSICAL CHARACTERISTICS

SHAPE:	Spherical beads
SHIPPING WEIGHT:	43 lbs/ft³ (688 g/l)
PARTICLE SIZE (U.S. MESH):	

Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5

PERFECT BEADS: 95% minimum

CHEMICAL CHARACTERISTICS

IONIC FORM:	Hydrogen/Hydroxide
CATION TO ANION EQUIVALENT RATIO:	1:1

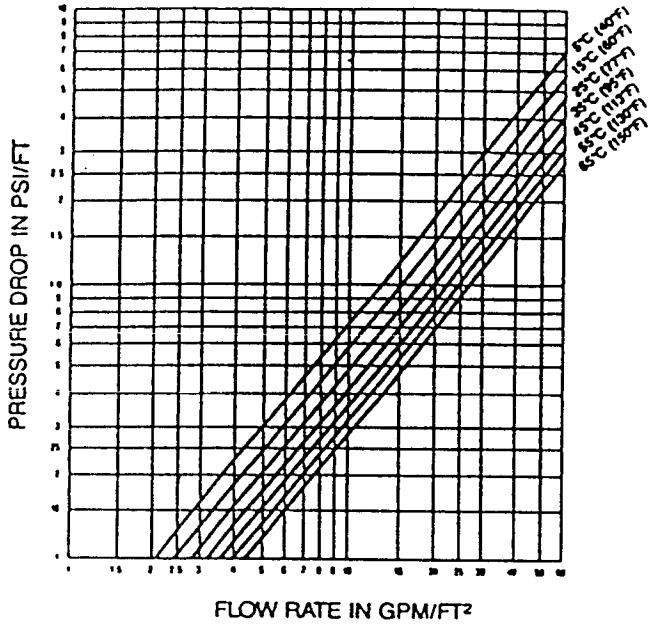
Ionic Content by Individual Component:	IRN-77	IRN-78
Equivalent % H, minimum	99.0	na
Equivalent % OH, minimum	na	95.0
Equivalent % Cl, maximum	na	0.10
Equivalent % CO_3, maximum	na	5.0
Equivalent % SO_4, maximum	na	0.10
Sodium (ppm dry resin) maximum	50	50
Iron (ppm dry resin) maximum	50	50
Copper (ppm dry resin) maximum	10	10
Heavy metals as Pb (ppm dry resin) maximum	10	10
Aluminum (ppm dry resin) maximum	50	50
Calcium (ppm dry resin) maximum	50	50
Magnesium (ppm dry resin) maximum	50	50

HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-150 resin in normal down flow operation at various temperatures and flow rates is shown in the graph below.

RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO_2 pickup and subsequent loss of capacity of the anion resin.

AMBERLITE® IRN-150 RESIN
PRESSURE DROP



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45
PSI/ft to MH₂O/M resin = PSI/ft x 2.30

APPLICATIONS

MIXED BED DEIONIZATION: The physical and chemical characteristics of Amberlite IRN-150 resin provide excellent performance when used in production of high quality water in any mixed bed deionization application.

NUCLEAR APPLICATIONS: The purity and physical stability of Amberlite IRN-150 resin provides unsurpassed performance in nuclear applications such as chemistry control in primary water treatment. Amberlite IRN-150 resin can also be used for a variety of rad waste applications.

PRODUCTION OF ULTRA PURE WATER: Amberlite IRN-150 resin is an excellent choice for once through (non-regenerable) applications typically found in the final DI water processing for the semiconductor industry. Amberlite IRN-150 resin provides rapid rinse to 18 megohm, high capacity, and reliable production of the highest-quality water.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-150 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

APPENDIX II

MATERIAL SAFETY DATA SHEETS

UMPQUA RESEARCH COMPANY

P.O. BOX 791 - 626 N.E. DIVISION
MYRTLE CREEK, OREGON 97457
(503) 863-5201
FAX (503) 863-6199

MATERIAL SAFETY DATA SHEET

Feb. 20, 1991

--------IDENTIFICATION--------

PRODUCT #: 90021-47 NAME: MCV-RT Iodinated Resin

----------REACTIVITY DATA----------

Drying results in release of iodine vapor.
Stability: stable.
Conditions to avoid: Temperatures over 220 C.

Incompatibilities: Nitric Acid and other strong Oxidizing agents can cause explosion.
Materials to avoid: NH_3, Acetylene, Acetaldehyde, Active metals particularly powdered Al.
Reactions when mixed with ion exchange resins.
Hazardous combustion or decomposition products.
Styrene Monomer, Divinylbenzene
Toxic fumes of:
Carbon Monoxide and Carbon Dioxide
Nitrogen Oxides
Hazardous Polymerization
Will not occur.

----------SPILL OR LEAK PROCEDURES----------

Steps to be taken if material is released or spilled:
Wear respirator, chemical safety goggles, rubber boots and heavy rubber gloves.
Sweep up, place in a bag and hold for waste disposal.
Floor may be slippery.
Avoid raising dust.
Ventilate area and wash spill site after material pickup is complete.
Waste Disposal Method:
This material may be landfilled as ordinary trash.
Observe all Federal, State, and Local Laws.

---------PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE---------

OSHA/MSHA - approved respirator.
Mechanical exhaust.
Compatible Chemical resistant gloves.
Dry ion exchange resins expand when wetted, which may cause column to shatter.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. UMPQUA RESEARCH COMPANY SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT.

SIGMA® chemical company

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FROM ANYWHERE IN THE WORLD
MAILING ADDRESS: P.O. BOX 14508, ST. LOUIS, MO. 63178, U.S.A.

CABLE ADDRESS: SIGMACHEM TWX: 910-761-0593

ATTN: SAFETY DIRECTOR
UMPQUA RESEARCH COMPANY
P O BOX 791
MYRTLE CREEK OR 97457

EMERGENCY PHONE 1-314-771-5765

DATE: 07/22/86

CUST#: 4-073-87920 PO#: 245

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

STOCK #: IRA-68
PRODUCT #: A7018
CAS #: 9056-59-1

NAME: AMBERLITE RESIN FREE BASE FORM GEL TYPE

TOXICITY HAZARDS

DATA NOT AVAILABLE

HEALTH HAZARD DATA

ACUTE EFFECTS
MAY CAUSE EYE IRRITATION.
DUST OR PARTICLES MAY IRRITATE THE EYES AS ANY FOREIGN BODY.
FIRST AID
IF SWALLOWED, WASH OUT MOUTH WITH WATER. CALL A PHYSICIAN.
IN CASE OF SKIN CONTACT, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. REMOVE CONTAMINATED CLOTHING AND SHOES AND CALL A PHYSICIAN.
IF INHALED, REMOVE TO FRESH AIR. IF BREATHING BECOMES DIFFICULT, CALL A PHYSICIAN.
IN CASE OF CONTACT WITH EYES, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. ASSURE ADEQUATE FLUSHING BY SEPARATING THE EYELIDS WITH FINGERS. CALL A PHYSICIAN.

PHYSICAL DATA

SPECIFIC GRAVITY: 1.06
SOLUBILITY: WATER-INSOLUBLE
APPEARANCE AND ODOR
OFF-WHITE BEADS, SLIGHT AMINE ODOR.

FIRE AND EXPLOSION HAZARD DATA

AUTOIGNITION TEMPERATURE: 427°C
EXTINGUISHING MEDIA
CARBON DIOXIDE.
DRY CHEMICAL POWDER.
WATER SPRAY.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

REACTIVITY DATA

STABILITY
STABLE.
CONDITIONS TO AVOID
TEMPERATURES ABOVE 220°C
INCOMPATIBILITIES
NITRIC ACID AND OTHER STRONG OXIDIZING AGENTS CAN FORM EXPLOSIVE TYPE REACTIONS WHEN MIXED WITH ION EXCHANGE RESINS.
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
ACRYLIC MONOMER, DIVINYLBENZENE

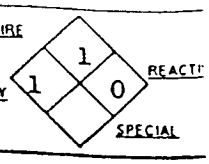
CONTINUED ON NEXT PAGE

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
*=SEE SECTION IV



BS242
LIST 7

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS
NOT WHMIS CONTROLLED

MATERIAL	CODE	KEY	DOT HAZARD CLASS
AMBERLITE® IRN-150 Resin	69855	891090-3	NON-REGULATED
	DATE ISSUED 11/08/88		

FORMULA	CHEMICAL NAME OR SYNONYMS
Not applicable	Mixed bed ion exchange resin (hydrogen and hydroxide forms)

I – COMPOSITIONAL INFORMATION

	CAS Reg. No.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Anion/cation exchange resin	NONHAZ	35-50	NE	NE	NE
Water	NONHAZ	50-65	NE	NE	NE

NE = None established

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH.			VISCOSITY
Beads; pH (aqueous slurry) = 5 to 9			NA
MELTING OR FREEZING POINT	**BOILING POINT**	**VAPOR PRESSURE (mm Hg)**	**VAPOR DENSITY (AIR=1)**
0C/32F (water)	100C/212F (water)	17 @20C (water)	Less than 1 (water)
SOLUBILITY IN WATER	**PERCENT VOLATILE (BY WEIGHT)**	**SPECIFIC GRAVITY (WATER=1)**	**EVAPORATION RATE (BUTYL ACETATE=1)**
Negligible	50-65 (water)	1.1-1.3	Less than 1 (water)

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
NA	500C/932F (est.)	NA	NA

EXTINGUISHING MEDIA

☐ FOAM ☐ "ALCOHOL" FOAM ☒ CO_2 ☒ DRY CHEMICAL ☒ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent) and full protective gear.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Toxic combustion products may include alkylamines and oxides of sulfur and nitrogen.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

STEL = None established.

EFFECTS OF OVEREXPOSURE

Eye Contact: Product can cause eye irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: Immediately flush eyes with large amounts of water and continue for at least minutes. Get prompt medical attention.

V – REACTIVITY INFORMATION

STABILITY	CONDITIONS TO AVOID
[X] STABLE [ ] UNSTABLE	Temperatures over 200C/392F.

HAZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition may yield styrene monomer, divinylbenzene, alkylamines and oxides of sulfur and nitrogen.

HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
[ ] MAY OCCUR [X] WILL NOT OCCUR	None known

INCOMPATIBILITY (MATERIALS TO AVOID) [ ] WATER [X] OTHER Avoid contact with concentrated nitric acid or any other strong oxidizing agent at all times.

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Floor may be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.

WASTE DISPOSAL METHODS Unused resin may be incinerated or landfilled in facilities meeting local, state and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE
Normal room ventilation.

RESPIRATORY PROTECTION
None required for normal operations.

PROTECTIVE GLOVES	EYE PROTECTION
None required	Safety glasses (ANSI Z-87.1 or approved equivalent)

OTHER PROTECTIVE EQUIPMENT
Eyewash facility

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 49C/120F MIN. 0C/32F	YES	NO	NO	YES

NOTE: Store at ambient temperatures. Avoid repeated freeze-thaw cycles.
NOTE: Ground ion exchange resins should be treated as potential eye irritants. A finely ground form of a structurally related strong acid cation exchange resin produced severe rabbit eye irritation.
NOTE: The maximum operating temperature for this product is 60C/140F. Functional group destruction and loss of capacity will occur above this temperature.

IX – TOXICITY INFORMATION

No toxicity data available for this product.

X – MISCELLANEOUS INFORMATION

Caution: Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause a glass column to shatter.
Caution: Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent rapid build-up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange beads, consult sources knowledgeable in handling these materials.
AMBERLITE® IS A TRADEMARK OF ROHM AND HAAS COMPANY OR ONE OF ITS SUBSIDIARIES OR AFFILIATES.

NA = NOT APPLICABLE C = CEILING VALUE	KEY	DATE OF ISSUE	SUPERSEDES
	891090-3	11/08/88	09/04/87

Rohm and Haas Company
Independence Mall West
Philadelphia, PA 19105

HEALTH EMERGENCY	: 215-592-3000
SPILL EMERGENCY	: 215-592-3000
OTHER	: 800-424-9300
CHEMTREC	: 800-424-9300

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTIFICATION

AMBERLITE® IRN-78 Resin

Product Code : 69837
Key : 892428-4
MSDS Date : 07/19/91
Supersedes : 11/07/88

Rohm and Haas Hazard Rating		Scale
Toxicity	1	4=EXTREME 3=HIGH 2=MODERATE 1=SLIGHT 0=INSIGNIFICANT
Fire	1	
Reactivity	0	
Special	-	

Product as supplied is a strongly basic anion exchange resin, hydroxide ion form.

COMPONENT INFORMATION

No.		CAS REG NO.	AMT.(%)
1	Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	35-50
2	Water	7732-18-5	50-65

EMERGENCY RESPONSE INFORMATION

FIRST AID PROCEDURES

Eye Contact

Flush eyes with a large amount of water for at least 15 minutes. Consult a physician if irritation persists.

Skin Contact

Wash affected skin areas thoroughly with soap and water.

FIRE FIGHTING INFORMATION

Unusual Hazards

Combustion generates toxic fumes of the following:
- nitrogen oxides

Extinguishing Agents

Use the following extinguishing media when fighting fires involving this material:
- carbon dioxide - dry chemical - water spray

CONTINUED

CONTINUATION

Personal Protective Equipment

Wear self-contained breathing apparatus (pressure-demand MSHA/NIOSH approved or equivalent) and full protective gear.

SPILL OR LEAK HANDLING INFORMATION

Personal Protection

Wear gloves made of the following material:
- butyl rubber

Additional personal protective equipment should include the following:
- safety glasses (ANSI Z87.1 or approved equivalent)

Procedures

Floor may be slippery; use care to avoid falling. Transfer spilled material to suitable containers for recovery or disposal.

HAZARD INFORMATION

HEALTH EFFECTS FROM OVEREXPOSURE

Eye Contact

Material can cause the following:
- irritation

Skin Contact

Prolonged or repeated skin contact can cause the following:
- slight skin irritation

FIRE AND EXPLOSIVE PROPERTIES

Flash Point	Not Applicable
Auto-ignition Temperature	500°C/932°F Estimate
Lower Explosive Limit	Not Applicable
Upper Explosive Limit	Not Applicable

REACTIVITY INFORMATION

Instability

This material is considered stable under specified conditions of storage, shipment and/or use. See **STORAGE AND HANDLING INFORMATION** Section for specified conditions. However, avoid temperatures above 200C/392F.

CONTINUED

CONTINUATION

Hazardous Decomposition Products

Thermal decomposition may yield the following:
- divinylbenzene - styrene monomer - alkylamines - oxides of nitrogen

Hazardous Polymerization

Product will not undergo polymerization.

Incompatibility

Avoid contact with strong oxidizing agents, particularly concentrated nitric acid.

ACCIDENT PREVENTION INFORMATION

COMPONENT EXPOSURE INFORMATION

Component Information

No.		CAS REG NO.	AMT.(%)
1	Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	35-50
2	Water	7732-18-5	50-65

Exposure Limit Information

Component No.	Units	ROHM AND HAAS TWA	ROHM AND HAAS STEL	OSHA TWA	OSHA STEL	ACGIH TLV	ACGIH STEL
1		None	None	None	None	None	None
2		None	None	None	None	None	None

PERSONAL PROTECTION MEASURES

Respiratory Protection

A respiratory protection program meeting OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. None required under normal operating conditions.

Eye Protection

Use safety glasses (ANSI Z87.1 or approved equivalent).

Hand Protection

Chemically resistant gloves should be worn whenever this material is handled.

CONTINUED

CONTINUATION

Gloves should be removed and replaced immediately if there is any indication of degradation or chemical breakthrough.

FACILITY CONTROL MEASURES

Ventilation

The ventilation system employed is dependent on the user's specific application of this material. Refer to the current edition of Industrial Ventilation: A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists for information on the design, installation, use, and maintenance of exhaust systems.

Other Protective Equipment

Facilities storing or utilizing this material should be equipped with an eyewash facility.

STORAGE AND HANDLING INFORMATION

Storage Conditions

The minimum recommended storage temperature for this material is 0C/32F. The maximum recommended storage temperature for this material is 49C/120F. Avoid repeated freeze-thaw cycles; beads may fracture.

Handling Procedures

The maximum recommended operating temperature for this material is 60C/140F. NOTE: This product as supplied is a whole bead ion exchange resin and may produce slight eye irritation. However, the ground form of this strong base anion exchange resin should be treated as a severe eye irritant. Worker exposure to ground resins can be controlled with local exhaust ventilation at the point of dust generation, or the use of suitable personal protective equipment (dust/mist air-purifying respirator and safety goggles).
Properly designed equipment is vital if these ion exchange resins are to be used in conjunction with strong oxidizing agents such as nitric acid to prevent a rapid build-up of pressure and possible explosion. Consult a source knowledgeable in the handling of these materials before preceding. Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause glass columns to shatter.

SUPPLEMENTAL INFORMATION

TYPICAL PHYSICAL PROPERTIES

State	Beads
pH	9.5-11.0
Viscosity	Not Applicable

CONTINUED

CONTINUATION

Specific Gravity (Water = 1)	1.0-1.4
Vapor Density (Air = 1)	< 1 Water
Vapor Pressure	17 mm Hg @20°C/68°F Water
Melting Point	0°C/32°F Water
Boiling Point	100°C/212°F Water
Solubility in Water	Practically insoluble
Percent Volatility	50-65 % Water
Evaporation Rate (BAc = 1)	< 1 Water

TOXICITY INFORMATION

Acute Data

No toxicity data are available for this material.

WASTE DISPOSAL

Procedure

Unused resin may be incinerated or landfilled in facilities meeting local, state, and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

REGULATORY INFORMATION

WORKPLACE CLASSIFICATIONS

This product is considered non-hazardous under the OSHA Hazard Communication Standard (29CFR 1910.1200).

This product is not a 'controlled product' under the Canadian Workplace Hazardous Materials Information System (WHMIS).

TRANSPORTATION CLASSIFICATIONS

US DOT Hazard Class . . . . . NONREGULATED

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3)

Section 311/312 Categorizations (40CFR 370)

This product is not a hazardous chemical under 29CFR 1910.1200, and therefore is not covered by Title III of SARA.

Section 313 Information (40CFR 372)

This product does not contain a chemical which is listed in Section 313 above de minimis concentrations.

ERCLA INFORMATION (40CFR 302.4)

Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committees under the Superfund Amendments and Reauthorization Act (SARA) Title III Section 304.

CRA INFORMATION

When a decision is made to discard this material as supplied, it does not meet RCRA's characteristic definition of ignitability, corrosivity, or reactivity, and is not listed in 40 CFR 261.33. The toxicity characteristic (TC), however, has not been evaluated by the Toxicity Characteristic Leaching Procedure (TCLP).

HEMICAL CONTROL LAW STATUS

All components of this product are listed or are excluded from listing on the U.S. Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

ABBREVIATIONS:

ACGIH = American Conference of Governmental Industrial Hygienists
OSHA = Occupational Safety and Health Administration
TLV = Threshold Limit Value
PEL = Permissible Exposure Limit
TWA = Time Weighted Average
STEL = Short-Term Exposure Limit
BAc = Butyl acetate
Bar denotes a revision from previous MSDS in this area.

5

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CABLE ADDRESS: SIGMACHEM TWX 910-761-0593

MATERIAL SAFETY DATA SHEET

STOCK #: IRA-68 CUST#: 4-073-87920 PO#: 245

PRODUCT #: A7018 NAME : AMBERLITE RESIN FREE BASE FORM GEL TYPE

REACTIVITY DATA

TOXIC FUMES OF:
CARBON MONOXIDE AND CARBON DIOXIDE
NITROGEN OXIDES
HAZARDOUS POLYMERIZATION
WILL NOT OCCUR.

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR RESPIRATOR, CHEMICAL SAFETY GOGGLES, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
FLOOR MAY BE SLIPPERY
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
ASTE DISPOSAL METHOD
THIS MATERIAL MAY BE LANDFILLED AS ORDINARY TRASH.
OBSERVE ALL FEDERAL, STATE, AND LOCAL LAWS.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

OSHA/MSHA-APPROVED RESPIRATOR.
MECHANICAL EXHAUST.
COMPATIBLE CHEMICAL RESISTANT GLOVES.
CHEMICAL SAFETY GOGGLES.
DRY ION EXCHANGE RESINS EXPAND WHEN WETTED, WHICH MAY CAUSE COLUMN TO SHATTER.

OFFICES AT: SIGMA LONDON CHEM CO LTD
FANCY ROAD, POOLE, DORSET BH17 7NH ENGLAND

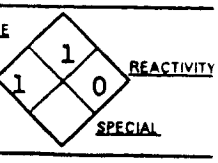
SIGMA CHEMIE GmbH MUNCHEN
A M BAHNSTEIG 7 D-8026 TAUFKIRCHEN WEST GERMANY

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
**=SEE SECTION IV



SE117
LIST 7

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS

MATERIAL	CODE	KEY	DOT HAZARD CLASS
AMBERLITE® IRN-77 Resin	69213	906197-1	NONREGULATED
	DATE ISSUED	07/31/87	

FORMULA	CHEMICAL NAME OR SYNONYMS
Not applicable	Strong acid cation exchange resin (hydrogen form)

I – COMPOSITIONAL INFORMATION

	CAS REG. NO.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Styrene/divinylbenzene cation exchange resin	NONHAZ	40-50	NE	NE	NE
Water	NONHAZ	50-60	NE	NE	NE

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE - ODOR - pH.			VISCOSITY
Beads; pH (aqueous slurry) 3.0 max.			NA
MELTING OR FREEZING POINT	BOILING POINT	VAPOR PRESSURE (mm Hg)	VAPOR DENSITY (AIR=1)
0C/32F (water)	100C/212F (water)	17 @ 20C/68F	Less than 1
SOLUBILITY IN WATER	PERCENT VOLATILE (BY WEIGHT)	SPECIFIC GRAVITY (WATER=1)	EVAPORATION RATE (BUTYL ACETATE=1)
Negligible	50-60 (water)	1.1-1.4	Less than 1

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
NA	427C/800F (est.)	NA	NA

EXTINGUISHING MEDIA

☐ FOAM ☐ "ALCOHOL" FOAM ☒ CO_2 ☒ DRY CHEMICAL ☒ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent) and full protective gear.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Toxic combustion products include oxides of sulfur. NOTE: See Section X for possible reactivity with nitric acid and other strong oxidizers.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

STEL = None established

EFFECTS OF OVEREXPOSURE

Eye Contact: Product, as supplied, can cause eye irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: Flush eyes with large amounts of water for at least 15 minutes. Get prompt medical attention.

FORM SP00 REV 1/1/

V – REACTIVITY INFORMATION

STABILITY: [X] STABLE [ ] UNSTABLE

CONDITIONS TO AVOID: Temperatures over 200C/392F.

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may yield styrene monomer, divinylbenzene, and sulfur oxides.

HAZARDOUS POLYMERIZATION: [ ] MAY OCCUR [X] WILL NOT OCCUR

CONDITIONS TO AVOID: None known

INCOMPATIBILITY (MATERIALS TO AVOID): [ ] WATER [X] OTHER — Avoid contact with concentrated nitric acid or any other strong oxidizing agents at all times.

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Floor may be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.

WASTE DISPOSAL METHODS: Unused resin may be incinerated or landfilled in facilities meeting local, state and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE: Normal room ventilation.

RESPIRATORY PROTECTION: None required for normal operations.

PROTECTIVE GLOVES: None required

EYE PROTECTION: Safety glasses (ANSI Z-87.1 or approved equivalent)

OTHER PROTECTIVE EQUIPMENT: Eyewash facility

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 60C/140F MIN. 0C/32F	YES	NO	NO	YES

NOTE: Store at ambient temperatures. Avoid repeated freeze-thaw cycles.

NOTE: Ground ion exchange resins should be treated as potential eye irritants. A finely ground form of a structurally related strong acid cation exchange resin produced severe rabbit eye irritation.

NOTE: The maximum operating temperature for this product is 121C/250F. Functional group destruction and loss of capacity will occur above this temperature.

IX – TOXICITY INFORMATION

No toxicity data available for this product.

X – MISCELLANEOUS INFORMATION

Caution: Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause a glass column to shatter.

Caution: Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent rapid build-up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange beads, consult sources knowledgeable in handling these materials.

NA = NOT APPLICABLE C = CEILING VALUE	KEY	DATE OF ISSUE	SUPERSEDES
	906197-1	11/02/88	07/31/87

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

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HAZARD RATING
4=EXTREME
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2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
**=SEE SECTION IV

FIRE 1 | REACTI 1 | TOXICITY 0 | SPECIAL

BS242
LIST 7

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS
NOT WHMIS CONTROLLED

MATERIAL	CODE	KEY	DOT HAZARD CLASS
AMBERLITE® IRN-150 Resin	69855	891090-3	NON-REGULATED
	DATE ISSUED 11/08/88		

FORMULA	CHEMICAL NAME OR SYNONYMS
Not applicable	Mixed bed ion exchange resin (hydrogen and hydroxide forms)

I – COMPOSITIONAL INFORMATION

	CAS Reg. No.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Anion/cation exchange resin	NONHAZ	35-50	NE	NE	NE
Water	NONHAZ	50-65	NE	NE	NE

NE = None established

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH.			VISCOSITY
Beads; pH (aqueous slurry) = 5 to 9			NA
MELTING OR FREEZING POINT	**BOILING POINT**	**VAPOR PRESSURE (mm Hg)**	**VAPOR DENSITY (AIR=1)**
0C/32F (water)	100C/212F (water)	17 @20C (water)	Less than 1 (water)
SOLUBILITY IN WATER	**PERCENT VOLATILE (BY WEIGHT)**	**SPECIFIC GRAVITY (WATER=1)**	**EVAPORATION RATE (BUTYL ACETATE=1)**
Negligible	50-65 (water)	1.1-1.3	Less than 1 (water)

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
NA	500C/932F (est.)	NA	NA

EXTINGUISHING MEDIA

☐ FOAM ☐ "ALCOHOL" FOAM ☒ CO_2 ☒ DRY CHEMICAL ☒ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent) and full protective gear.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Toxic combustion products may include alkylamines and oxides of sulfur and nitrogen.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

STEL = None established.

EFFECTS OF OVEREXPOSURE

Eye Contact: Product can cause eye irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: Immediately flush eyes with large amounts of water and continue for at least 15 minutes. Get prompt medical attention.

FORM BS242 REV. 11/88

APPENDIX D

Document #: 80279
Revision:
Date Released: 4-28-92

UNIBED SORBENT SIZING CALCULATIONS

OF THE POSTTREATMENT UNIBED FOR THE CATALYTIC OXIDATION SYSTEM BEING FED PRETREATED HUMIDITY CONDENSATE

FOR THE

NASA-MSFC PHASE II SBIR:

CATALYTIC METHODS USING MOLECULAR OXYGEN FOR TREATMENT OF PMMS AND ECLSS WASTE STREAMS

Prepared By: _____

Approved By: _____ Date: 4-28-92

Approved By: _____ Date: 4.28.92

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

1.0 INTRODUCTION

This document presents the design for the Posttreatment Unibed which will be used to treat the effluent from a catalytic oxidation system being fed pretreated humidity condensate. The humidity condensate's composition is shown in Table 1. After passage through the pretreatment bed only the alcohols, dimethyl phthalate, dibutyl amine, and thiourea remain. After passage of this solution through the catalytic oxidation system, the majority of these organic species will be converted to carbon dioxide and water. Organic sulfur will be oxidized to sulfate anions. Organic nitrogen is either oxidized to nitrogen gas or converted to ammonium ions depending on the contact time. This Unibed is designed to remove these inorganic species as well as any oxidized organic species which are present at very low levels. The effluent from this bed should meet or surpass the NASA potable water requirements shown in Table 2. This Unibed will be installed downstream of the catalytic oxidation system. (see Figure 1)

1.1 Application Documents

1.1.1 SBIR Phase II Contract NAS8-38490

1.2 Application Drawings

1.2.1 Umpqua Research: URC DWG 90212

1.3 General Approach

The design is based on (1) isotherm data from shaker table and small column single contaminant, single media tests performed at UMPQUA under the following NASA

Table 1

ERSATZ HUMIDITY CONDENSATE

Organics

	mg/liter	TOC (mg/liter)
Caprylic Acid	0.537	0.358
Dibutylamine	7.28	5.412
Dimethyl Phthalate	0.548	0.339
Ethanol	14.00	7.300
Formic Acid	1.65	0.431
Isopropanol	0.87	0.522
Lactic Acid	0.93	0.372
Methanol	1.54	0.577
Propanoic Acid	0.871	0.424
Thiourea	14.56	2.298
	42.79 mg/liter	18.03 mg/liter

Inorganics

Ammonium Hydroxide	36.3
Ammonium Phosphate	0.53
Ammonium Sulphate	0.25
Calcium Chloride	0.15
Sodium Chloride	0.36
Sodium Fluoride	0.49
Sodium Nitrate	0.36
	38.44 mg/liter

TABLE 2. WATER QUALITY REQUIREMENTS
(Maximum Contaminant Levels)

QUALITY PARAMETERS	POTABLE WATER
PHYSICAL PARAMETERS	
Total Solids (mg/l)	100
Color, True (Pt/Co units)	15
Taste (TTN)	3
Odor (TON)	3
Particulates (max size - microns)	40
pH	6.0-8.5
Turbidity (NTU)	1
Dissolved gas (free @ 37 C)	Note 1
Free gas (@ STP)	Note 1
INORGANIC CONSTITUENTS (mg/l) (See Note 2)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chloride	200
Chromium	0.05
Copper	1.0
Iodine (Total-includes organic iodine)	15
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO_3-N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0

TABLE 2. WATER QUALITY REQUIREMENTS (Continued)
(Maximum Contaminant Levels)

QUALITY PARAMETERS	POTABLE WATER
ASTHETICS (mg/l)	
Cations	30
Anions	30
CO_2	15
MICROBIAL	
Bacteria (CFU/100 ml)	
Total Count	1
Anaerobes	1
Coliform	1
Virus (PFU/100 ml)	1
Yeast & Mold (CFU/100 ml)	1
RADIOACTIVE CONSTITUENTS (pCi/l)	Note 3
ORGANIC PARAMETERS (µg/l) (See Note 2)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Phenols	1
Total Alcohols	500
Total Organic Carbon (TOC)	500
Uncharacterized TOC (UTOC)(See Note 4)	100
ORGANIC CONSTITUENTS (mg/l) (See Note 2)	

Note 1: No detectable gas using a volumetric gas vs fluid measurement system. Excludes CO_2 used for aesthetic purposes.

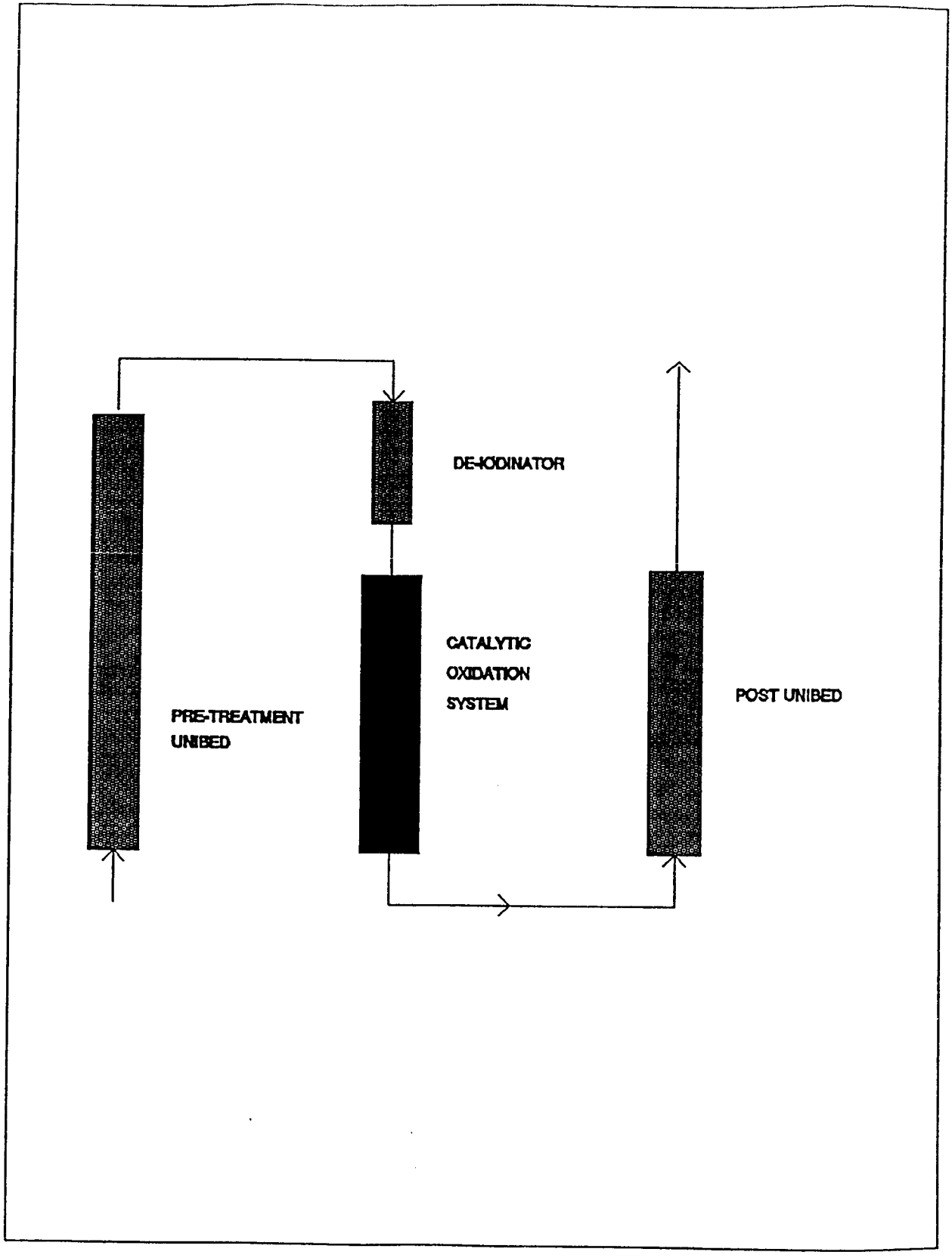
Note 2: Each parameter/constituent MCL must be considered individually and independently of others.

Note 3: The maximum contaminant levels for radioactive constituents in potable and personal hygiene water shall conform to Nuclear Regulatory Commission (NRC) regulations (10CFR20, et al.). These maximum contaminant levels are listed in the Federal Register, Vol. 51, No. 6, 1986, Appendix B, as Table 2 (Reference Level Concentrations) Column 2 (Water). Control/contaminant/monitoring of radioactive constituents used on SSF shall be the responsibility of the user. Prior to the introduction of any radioactive constituents on SSF, approval shall be obtained from the Radiation Constraints Panel (RCP). The RCP will approve or disapprove proposed monitoring and decontamination procedures on a case-by-case basis.

Note 4: UTOC equals TOC minus the sum of analyzed organic constituents expressed in equivalent TOC.

FIGURE 1

BED LOCATION



contracts: NAS9-17073, NAS9-17464, NAS9-17523, and NAS9-17611 and (2) manufacturer's stated ion exchange capacity.

2.0 DESIGN REQUIREMENTS

2.1 Configuration

2.1.1 One 15 in long, 2 in diameter stainless steel tube with inner teflon coating and 1/8 " pipe thread elbows at the inlet and outlet.

2.2 Life at Design Conditions

2.2.1 Throughput: 720 L

2.2.2 Time: 50 days

2.3 Inlet Solution

2.3.1 Effluent from Catalytic Oxidation Reactor (Table 3)

2.4 Flow

2.4.1 Flow Rate: 10 mL/min ≈ 0.6 L/hr (1.32 lb/hr)

2.4.2 Daily Operating Time: 24 hr/day

2.4.3 1-Day Throughput: 14.4 L

2.5 Temperature

2.5.1 Operating Range: 68 - 77 F

2.6 Pressure

2.6.1 Maximum Operating Pressure (MOP): 40 psig

2.6.2 Proof Pressure: 60 ± 5 psig

2.7 Pressure Drop

2.7.1 Maximum Allowable Pressure Drop: 5 psig

2.8 Iodine Output

2.7.1 Range: 0.5 - 4.0 ppm

2.9 Outlet Quality

2.9.1 Water Quality Requirements: See Table 2. (NOTE: This standard applies prior to iodination.)

3.0 DESIGN DATA

The design data were developed by UMPQUA under contract to NASA-JSC for the ion exchange and MCV media (see paragraph 1.3 for applicable contract numbers).

3.1 Sorbent Selection

The best performing media have been selected for each bed, based on single adsorbent-single contaminant/shaker table and single adsorbent-single contaminant/dynamic column tests run previously by UMPQUA. The selected adsorbents are listed in Table 3.

3.2 Adsorption Equilibrium Data

Table 3 also contains ion exchange loadings (equilibrium data) necessary for the design of the sorption sub-beds. These data are from UMPQUA small-column tests and are lower than the manufacturer's published values.

4.0 UNIBED DESIGN

4.1 Unibed Dimensions

The unibed consists of a single 2 in x 15 in long stainless steel housing containing nominally, 636 cc of media. The total bed length is 12.5 in. A sub-bed volume

of 60 cc provides the minimum bed length to diameter ratio necessary to insure proper sub-bed performance. The remaining volume is occupied by lip seals, an internal spring and the end caps.

TABLE 3. POSTTREATMENT UNIBED (DIRECT HUMIDITY CONDENSATE INFLUENT)

CONTAMINANT	CONCENTRATION (meq/liter)		MFG's' CAPACITY (meq/cm^3)	URC DESIGN CAPACITY (mg/cm^3)	SWELLING %
Sulphate	0.39	IRN 78	1.2 0.8	57.6 38.4	-30 -20
		IRN 150			
Ammonium	0.017	IRN 150	0.8	14.4	-20
Organic Acids	1.39×10^{-5}	IRA 68	1.6	4.9	+20

* * * * * * * * * *

TABLE 4. POSTTREATMENT UNIBED MEDIA CONFIGURATION

Flow Direction	Sorbent	Ref. Para	Volume (cm^3)	Function
↓	MCV-RT	9.2.1	60	Microbial Control
↓	IRN 150	4.2.2	60	Remove Anions/ Cations
↓	IRN 78	4.2.3	306	Remove Inorganic Anions
↓	IRA 68	4.3.4	150	Remove Organic Acids
↓	IRN 150	4.2.1	60	Microbial Control

4.2 Unibed Configuration and Sub-bed Sizing

The configuration of the posttreatment bed is shown in Table 4. The MCV-RT resin sub-bed maintains the sterile integrity of the Unibed. The IRN 78 sub-bed removes sulphate which is generated by thiourea oxidation. The next sub-bed consists of IRA 68, a weak base ion exchange resin, which removes oxidized organic species such as organic acids. The IRN 150 sub-bed removes any ammonium generated by organic nitrogen oxidation. This bed also adjusts the pH to neutral values. The final MCV-RT resin sub-bed imparts iodine into the effluent for microbial control. The sizing rationale for each sub-bed is presented in the following paragraphs.

4.2.1 MCV-RT

MCV-RT resin is required at the entrance for microbial control within the bed. This resin puts out 0.5 to 4.0 ppm of I_2 and has a capacity of 50 liters/cm^3 of media.

Life:

60 cm^3 x 50 L/cm^3 ÷ 14.4 L/day = 208 days

4.2.3 IRN 78

IRN 78 removes anions which in this case predominantly consist of sulphate originating from thiourea. The concentration of sulphate is given by: $SO_4^=$ = 0.39 meq/L. The 306 cm^3 sub-bed will hold 1.2 meq/cm^3.

Total Sorption Capacity:

306 cm^3 x 1.2 mg/cm^3 = 367.2 meq

Throughput Capacity:

367.2 meq ÷ 0.39 meq/L = 937.2 L

Life: 937.2 L ÷ 14.4 L/day = 65 days

4.2.4 IRA 68

The organics which remain in the catalytic oxidation system's effluent are highly oxidized, low molecular weight species which are likely to be organic acids. Their concentrations are low and variable. Taking the average concentration to correspond to a total organic carbon level of 0.5 mg/liter, the potable water limit, and the average composition to be approximated by propanoic acid, then the total concentration will be 1.03 mg/liter.

IRA 68 will remove these organic acids. The capacity, based on four low molecular weight organic acids, is 4.9 mg/cm^3.

Total Sorption Capacity: 150 cm^3 x 4.9 mg/cm^3 = 735 mg

Throughput Capacity: 735 ÷ 1.028 mg/l = 715 L

Life: 715 L ÷ 14.4 l/day = 50 days

4.2.2 IRN 150

This bed is primarily designed for pH control. Since the ammonium level is low, it will exercise little effect on the subbeds performance. The concentration of ammonium and sulphate is given by:

NH_4^+ = 0.017 meq/L and $SO_4^=$ = 0.3912 meq/L.

The 60 cm^3 bed will remove 0.8 meq/cm^3 of both cations and anions.

Total Anionic and Cationic Sorption Capacity:

60 cm^3 x 0.8 meq/cm^3 = 48 meq

Anionic Throughput Capacity:

48 meq ÷ 0.3912 meq/L = 122.7 L

Cationic Throughput Capacity:

48 meq ÷ 0.017 mg/L = 2824 L

Anionic Life: 122.7 L ÷ 14.4 L/day = 9 days

Cationic Life: 2824 L ÷ 14.4 L/day = 196 days

4.2.5 MCV-RT

Life: 60 cm^3 x 50 L/cm^3 ÷ 14.4 L/day = 208 days

4.2.6 Sizing Discussion

The design summarized in Table 5 was obtained within the dimension constraints in Paragraph 4.1. The capacity is limited by the overall bed size. The limiting factor is the bed life of the IRA 68 sub-bed which is 50 days. This bed life is a worst case scenario and the actual bed life should be longer.

4.3 Pressure Drop

Previous testing developed a pressure drop equation.

$$\delta P = 0.4\ WL\ \mu/D^2$$

where:

δP = Pressure drop, psi

W = flow rate, lb/min

L = bed length, in

D = bed diameter, in

μ = viscosity, centipoise

For the post bed:

W = 1.32 lb/hr = 0.022 lb/min

L = 12.5 in

D = 2 in

μ = 1 centipoise

$\delta P = 0.4\ (0.022)(12.5)(1)/(2)^2 = 0.03$ psi

Specified max δP = 5.0 psi

4.4 Summary of Unibed Design Values

A summary of the design values for the beds is given in Table 5.

TABLE 5. SUMMARY OF POST UNIBED DESIGN VALUES

Parameter	Value
URC Drawing Number	90212
Nominal ID	2 in
Water System	Potable
Flow Rate	1.32 lb/hr (0.6 L/hr)
Daily Operating Time	24 hr/day
Thruput, 1 day	14.4 L
Total Media volume	636 cc
Cross Sectional Area	20.3 cm^2
Total Length of Media (Installed)	12.35 in
Face Velocity	0.493 cm/min
Empty Bed Contact Time	63.6 min
Life (limited by IRA-68)	720 L, 50 days

APPENDIX I

MEDIA INFORMATION

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRN-150

Amberlite IRN-150 is a mixture of gelular, polystyrene cation and anion exchange resins. Amberlite IRN-150 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation (Amberlite IRN-77) and the strongly basic anion (Amberlite IRN-78) exchange resins. It is supplied in the hydrogen/hydroxide form as clear, amber colored spherical particles virtually perfect in bead appearance. Amberlite IRN-150 resin is designed for use in industrial water treatment applications, particularly in once through applications such as primary water chemistry control in nuclear power operations. This resin combines the properties of high capacity and excellent resistance to bead fracture from attrition or osmotic shock.

Amberlite IRN-150 resin is designated as a Nuclear Grade resin and is manufactured using special processing procedures. These procedures, combined with a patented Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry. Amberlite IRN-150 resin is recommended in any non-regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non-ionic contamination.

IMPORTANT FEATURES OF AMBERLITE IRN-150 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-150 resin will exhibit a nominal operating capacity of 12 kg/ft³ (0.55 meq/ml).

EXCEPTIONAL PURITY: Amberlite IRN-150 resin is manufactured to demanding purity specifications which assure a minimum of ionic and non-ionic contamination.

GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-150 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

RECOMMENDED CONDITIONS OF OPERATION

The recommended conditions for operation of Amberlite IRN-150 resin are listed below.

BED DEPTH: 24" minimum (0.61 m)

SERVICE FLOW RATE: 2–5 gpm/ft³ (16 to 40.1 l/hr/l)

PHYSICAL CHARACTERISTICS

SHAPE: Spherical beads

SHIPPING WEIGHT: 43 lbs/ft³ (688 g/l)

PARTICLE SIZE (U.S. MESH):

Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5

PERFECT BEADS: 95% minimum

CHEMICAL CHARACTERISTICS

IONIC FORM: Hydrogen/Hydroxide

CATION TO ANION EQUIVALENT RATIO: 1:1

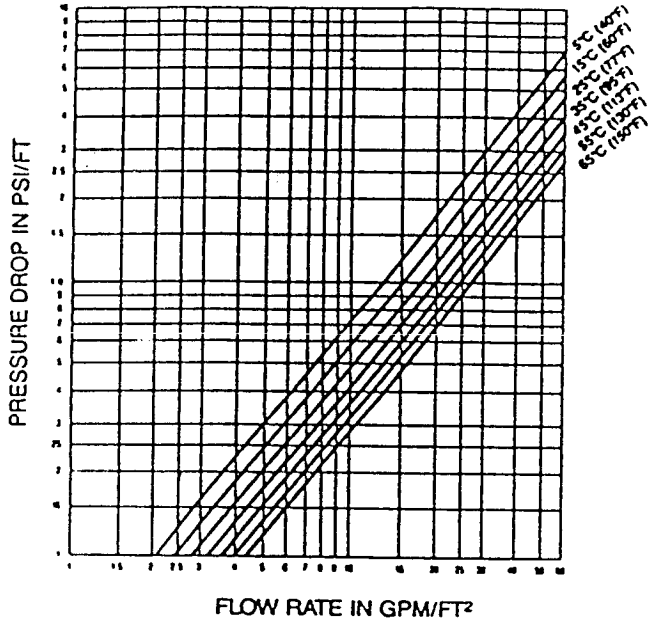
Ionic Content by Individual Component:	IRN-77	IRN-78
Equivalent % H, minimum	99.0	na
Equivalent % OH, minimum	na	95.0
Equivalent % Cl, maximum	na	0.10
Equivalent % CO_3, maximum	na	5.0
Equivalent % SO_4, maximum	na	0.10
Sodium (ppm dry resin) maximum	50	50
Iron (ppm dry resin) maximum	50	50
Copper (ppm dry resin) maximum	10	10
Heavy metals as Pb (ppm dry resin) maximum	10	10
Aluminum (ppm dry resin) maximum	50	50
Calcium (ppm dry resin) maximum	50	50
Magnesium (ppm dry resin) maximum	50	50

HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-150 resin in normal down flow operation at various temperatures and flow rates is shown in the graph below.

RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO_2 pickup and subsequent loss of capacity of the anion resin.

AMBERLITE® IRN-150 RESIN
PRESSURE DROP



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² × 2.45
PSI/ft to MH₂O/M resin = PSI/ft × 2.30

APPLICATIONS

MIXED BED DEIONIZATION: The physical and chemical characteristics of Amberlite IRN-150 resin provide excellent performance when used in production of high quality water in any mixed bed deionization application.

NUCLEAR APPLICATIONS: The purity and physical stability of Amberlite IRN-150 resin provides unsurpassed performance in nuclear applications such as chemistry control in primary water treatment. Amberlite IRN-150 resin can also be used for a variety of rad waste applications.

PRODUCTION OF ULTRA PURE WATER: Amberlite IRN-150 resin is an excellent choice for once through (non-regenerable) applications typically found in the final DI water processing for the semiconductor industry. Amberlite IRN-150 resin provides rapid rinse to 18 megohm, high capacity, and reliable production of the highest-quality water.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-150 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRN-78

ION EXCHANGE RESIN

Amberlite IRN-78 is a strongly basic gel type polystyrene anion exchange resin supplied in the hydroxide form. This resin is Nuclear Grade and processed to the highest purity standards required for treating water in the nuclear power industry. Amberlite IRN-78 contains a minimum of 95% of the exchange sites in the hydroxide form and a maximum of 0.10% in either the chloride or sulfate form. This is achieved by a patented Rohm and Haas low chloride regeneration process.

The manufacturing process for this resin is controlled to keep inorganic impurities, including chloride and sulfate, at the lowest possible levels. These two impurities are known to cause corrosion in the primary circuit and must be kept to a minimum. Special treatment procedures are also practiced to remove traces of soluble organic compounds. These high standards of resin purity will help to keep the nuclear systems free of contaminants and deposits and prevent increases in radioactivity levels due to activation of impurities as the water circulates through the reactor core.

IMPORTANT FEATURES OF AMBERLITE IRN-78 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-78 resin exhibits a minimum of 1.1 meq/ml.

EXCEPTIONAL PURITY: Amberlite IRN-78 resin is manufactured to demanding purity specifications which assure a minimum of ionic and nonionic contamination.

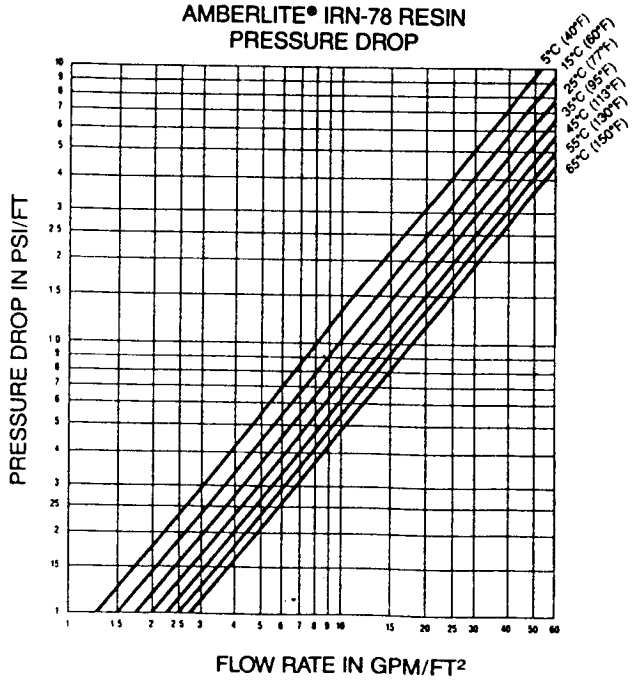
GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-78 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

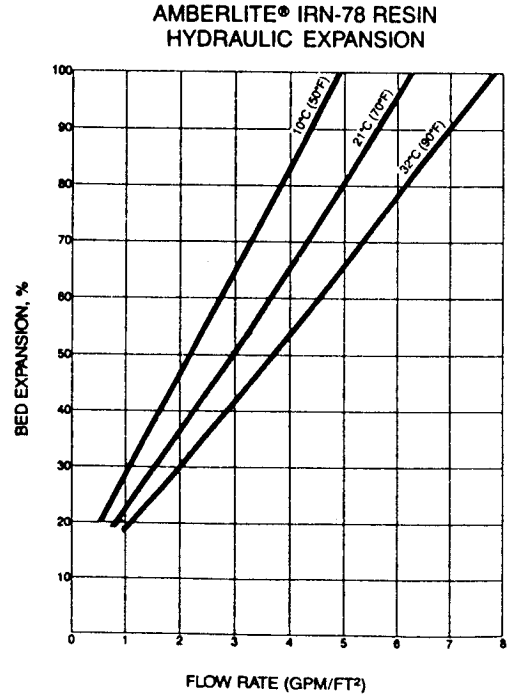
HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-78 resin in normal downflow operation at various temperatures and flow rates is shown in the graphs below (data based on backwashed and classified resin bed).

RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO_2 pickup and subsequent loss of capacity of the anion resin. If the resin requires backwashing the bed should be expanded a minimum of 50%.



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45
PSI/ft to MH_2O/M resin = PSI/ft x 2.30



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45

RECOMMENDED CONDITIONS OF OPERATION

BED DEPTH:	24" minimum (0.61 m)
TEMPERATURE:	140°F maximum (60°C)
SERVICE FLOW RATE:	1-5 gpm/ft³ (8.0 to 40.1 l/hr/l)

CHEMICAL CHARACTERISTICS

IONIC FORM:	Hydroxide
TOTAL EXCHANGE CAPACITY:	1.1 meq/ml minimum
MOISTURE CONTENT:	60% maximum
IONIC CONTENT:	
Equivalent % OH minimum	95.0
Equivalent % Cl maximum	0.10
Equivalent % CO_3 maximum	5.0
Equivalent % SO_4 maximum	0.10
METALS CONTENT:	
Sodium (ppm dry resin) maximum	50.0
Iron (ppm dry resin) maximum	50.0
Copper (ppm dry resin) maximum	10.0
Heavy Metals as Pb (ppm dry resin) maximum	10.0
Aluminum (ppm dry resin) maximum	50.0
Calcium (ppm dry resin) maximum	50.0
Magnesium (ppm dry resin) maximum	50.0

PHYSICAL CHARACTERISTICS

SHAPE:	Spherical beads
SHIPPING WEIGHT:	43 lbs/ft³ (688 g/l)
PARTICLE SIZE (U.S. MESH):	
Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5
CHATILLON:	
Avg., gm/bead	350 minimum
% 200 gm/bead	95 minimum
SOLUBILITY:	0.10% maximum
PERFECT BEADS:	95% minimum

APPLICATIONS

PRIMARY WATER TREATMENT: Amberlite IRN-78 resin is very effective in removing I^{131} I^{133} and trace Cl^- contamination from reactor coolant streams. It is also useful in controlling the boron level in the primary system.

RAD WASTE TREATMENT: Amberlite IRN-78 resin is very effective in removing radioactive anions such as Iodine 131 and 133 from waste streams.

DECONTAMINATION: Amberlite IRN-78 resin removes anionic radioactive material from spent decontaminating solutions.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-78 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

URC 80278

January 1986 Printed in U.S.A.

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
ID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRA-68

Amberlite IRA-68 is a gel type, weakly basic anion exchange resin possessing tertiary amine functionality in a crosslinked acrylic matrix. In addition to exhibiting a high exchange capacity, this resin has good chemical and thermal stability and is especially suited to the adsorption and desorption of organic materials from solution. Amberlite IRA-68 is also well suited for applications in the pharmaceutical, chemical and food processing industries for the neutralization of strong acids and other special processes.

IMPORTANT FEATURES OF AMBERLITE IRA-68

HIGH CAPACITY AND LOW COST REGENERATION—Amberlite IRA-68 has an operating acid removal exchange capacity of 29 kgrs/ft³ (66.4 g/l as $CaCO_3$) of resin. Regeneration is accomplished using 110-120% of the quantity of base chemically equivalent to the operating capacity. Thus, regenerant costs are significantly lower than for strongly basic resins and waste problems are held at a minimum.

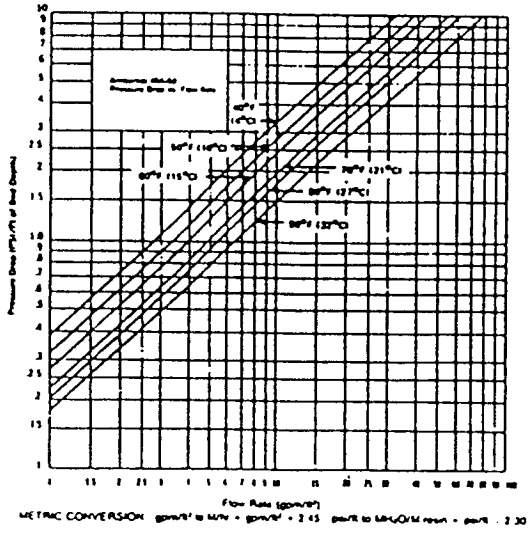
RESISTANCE TO ORGANIC FOULING—Amberlite IRA-68 is synthesized with an open structure which permits the effective adsorption and desorption of large organic molecules. Because of this open structure, organic materials are readily eluted from Amberlite IRA-68 resulting in no capacity loss due to organic fouling.

CHEMICAL FORM—Amberlite IRA-68 is shipped in the fully regenerated free-base form and can be utilized immediately for acid removal.

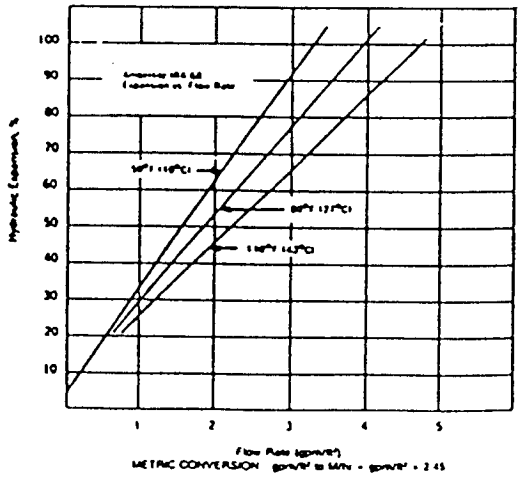
INSOLUBLE IN ALL COMMON SOLVENTS.

HYDRAULIC CHARACTERISTICS

PRESSURE DROP—The curves show the expected pressure drop per foot of bed depth in normal downflow operation at various temperatures as a function of flow rate.



BACKWASH CHARACTERISTICS—After each operational cycle Amberlite IRA-68 should be backwashed for approximately ten minutes to re-classify the resin particles and purge the bed of any insoluble material which may have collected on top of the resin. The resin bed should be expanded a minimum to 50% during backwash.



PHYSICAL CHARACTERISTICS

PHYSICAL FORM—Uniform, spherical particles shipped in moist, fully regenerated condition.

DENSITY—41 to 47 lbs/ft³ (656 to 752 g/l)

SHIPPING WEIGHT—45 lbs/ft³ (720 g/l)

MOISTURE CONTENT—60% as shipped *

SCREEN GRADING (WET)—16 to 50 mesh (U.S. Standard Screen)

EFFECTIVE SIZE—0.45 mm.*

FINES CONTENT—3% maximum

SWELLING—20%* upon complete conversion of the resin from the free base to the chloride form.

*Approximate

SUGGESTED OPERATING CONDITIONS

Limitation — 0 to 7
ximum Temperature — 140°F (60°C)
nimum Bed Depth — 24 inches (0.61 m)
:kwash Flow Rate — See detailed information
;enerant Concentration* —4%
;enerant Flow Rate — 0.5 to 1.0 gpm/ft³ (4.0 to 8.0 l/hr/l)
;eneration Level — See detailed information
e Flow Rate — 0.5 gpm/ft³ (4.0 l/hr/l) initially, to displace regenerant then 1.5 gpm/ft³ (12.0 l/hr/l)
ıse Water Requirements — 50 to 75 gal/ft³ (6.7 to 10.1 l/l)
vice Flow Rate — 1 to 3 gpm/ft³ (8.0 to 24.1 l/hr/l)
:hange Capacity — See detailed information
: Safe Handling Information section

REGENERATION LEVEL AND CAPACITY

minimum acid removal operating capacity of 28 kgrs. (as CO_2/ft³) (64 g/l) of resin may be expected using the follow- amounts of regenerants:
3.7 lbs of NaOH/ft³ (59.2 g/l) or
3.2 lbs of NH_4OH/ft³ (51.2 g/l) or
4.9 lbs of Na_2CO_3/ft³ (78.4 g/l)

APPLICATIONS

ONIZATION — The marked worldwide increase in the use of ylic anion exchange resins is illustrated by the increased ization of Amberlite IRA-458 as the strongly basic anion hange component of many deionization systems. Amberlite A-458 is installed when high capacity, excellent organic ling resistance, and good physical stability are required. Vhere plant design, however, dictates the use of a weakly ic anion exchange resin with properties comparable to those Amberlite IRA-458, Amberlite IRA-68 is the prime choice. Amberlite IRA-68 is a gelular acryic weakly basic anion hange resin with tertiary amine functionality. The acrylic trix of Amberlite IRA-68 is hydrophilic making it similar to it of Amberlite IRA-458. When compared with gelular poly- rene or epoxy-amine type resins, the acrylic matrix of iberlite IRA-68 shows superior kinetic behavior particularly regeneration elution of organics. This superior organic foul- resistance places Amberlite IRA-68 in the same class as *croreticular* styrene weakly base anion exchange resins. The flexible nature of the gelular acrylic matrix imparts ex- lent physical stability with regard to mechanical attrition, d osmotic shock. This, again, is normally attributed to a croreticular structure.

In contrast to most weakly basic anion exchange resins, the rking capacity of Amberlite IRA-68 is independent of service w rate (1.0 to 5.0 gpm/ft³ [8.0 to 40.1 l/hr/l]), temperature)°–70°F [4 to 21°C]), and only slightly affected by influent ter analysis changes. A base working capacity of 29.0 kgr/ft³ 6.4 g/l) can be expected under normal operating conditions.

The weakly basic anion exchange resin Amberlite IRA-68 incorporates the high working capacity of gel styrene and gel epoxy-amine weakly basic anion exchange resins, without the latter resins' inherent physical weaknesses and organic fouling tendencies. At the same time, it also incorporates the superior physical stability and organic fouling resistance associated with macroreticular weakly basic anion exchange resins, while avoiding the lower working capacities normally associated with macroreticular structure.

ACID MINE DRAINAGE — A modification of the DESAL Process for the treatment of acid mine drainage water has been developed in the Rohm and Haas laboratories. This process, utilizing Amberlite IRA-68 operating in the bicarbonate cycle, converts metallic sulfates, the principal anionic constituents of AMD waters, into soluble bicarbonates which when aerated precipitate as insoluble hydrous oxides. The resulting effluent water will contain calcium and magnesium hardness, which if desired, can be softened using a cold lime softening treatment.

DEIONIZATION AND ORGANIC SCAVENGING — Amberlite IRA-68 is particularly suited for the removal of strong acids and the deionization of process liquors. This resin should be considered for use in the deionization of water and special applications where high molecular weight materials are to be removed from solution.

DEASHING AND DECOLORING CORN SUGAR — When properly pretreated Amberlite IRA-68 is cleared for use in food processing under FDA Food Additive Regulation 21CFR-173.25. According to this regulation the food or aqueous flow must be maintained at 50°C or below, and the flow through the resin must be less than 0.5 gpm/ft³ (4.0 l/hr/l).

SAFE HANDLING INFORMATION — A Material Safety Data Sheet is available for Amberlite IRA-68. To obtain a copy contact your Rohm and Haas representative.

Caution: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

IE-120-67/80 June 1982 Printed in U.S.A.

APPENDIX II

MATERIAL SAFETY DATA SHEETS

UMPQUA RESEARCH COMPANY

P.O. BOX 791 - 626 N.E. DIVISION
MYRTLE CREEK, OREGON 97457
(503) 863-5201
FAX (503) 863-6199

MATERIAL SAFETY DATA SHEET

Feb. 20, 1991

----------IDENTIFICATION----------

PRODUCT #: 90021-47 NAME: MCV-RT Iodinated Resin

----------TOXICITY HAZARDS----------

Effects of Overexposure: Can irritate eyes, nose, throat and skin, hypersensitivity, nausea, abdominal pain, diarrhea, excessive thirst, circulatory failure. Possibly fatal if swallowed.

----------HEALTH HAZARD DATA----------

Threshold Limit Value
TVL-air: 0.1 ppm as Iodine TXDS: orl-Hmn LDLo: 5 mg/kg as Iodine
First Aid Procedures:
Skin: wash with soap/water; get medical assistance.
Eyes: flush thoroughly with water 15 minutes. Assure adequate flushing by separating the eyelids with fingers; get medical assistance.
Inhalation: remove to fresh air; get medical assistance.
Ingestion: give milk, starch solution, or tablespoon sodium thiosulfate in a glass of water and get immediate medical attention. Treat for shock.
Acute Effects: may cause eye irritation. Particles can irritate the eyes. Finely ground particles of similar material caused corneal damage in rabbit eyes.

----------PHYSICAL DATA----------

Specific Gravity: 1.11
Appearance and Odor: Dark purple to black beads, with moderate iodine and amine odor.
Solubility: Beads release iodine in water in concentrations below 300 ppm

----------FIRE AND EXPLOSION HAZARD DATA----------

Autoignition Temperature: 427 C EST
Extinguishing Media
Carbon Dioxide
Dry Chemical Powder
Water Spray
Special Firefighting Procedures
Wear Self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Unusual Fire and Explosions hazards
Emits Toxic fumes under fire conditions.

Rohm and Haas Company
Independence Mall West
Philadelphia, PA 19105

HEALTH EMERGENCY	: 215-592-3000
SPILL EMERGENCY	: 215-592-3000
OTHER	: 800-424-9300
CHEMTREC	: 800-424-9300

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTIFICATION

AMBERLITE® IRN-78 Resin

Product Code : 69837
Key : 892428-4
MSDS Date : 07/19/91
Supersedes : 11/07/88

Rohm and Haas Hazard Rating		Scale
Toxicity	1	4=EXTREME 3=HIGH 2=MODERATE 1=SLIGHT 0=INSIGNIFICANT
Fire	1	
Reactivity	0	
Special	-	

Product as supplied is a strongly basic anion exchange resin, hydroxide ion form.

COMPONENT INFORMATION

No.		CAS REG NO.	AMT.(%)
1	Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	35-50
2	Water	7732-18-5	50-65

EMERGENCY RESPONSE INFORMATION

FIRST AID PROCEDURES

Eye Contact

Flush eyes with a large amount of water for at least 15 minutes. Consult a physician if irritation persists.

Skin Contact

Wash affected skin areas thoroughly with soap and water.

FIRE FIGHTING INFORMATION

Unusual Hazards

Combustion generates toxic fumes of the following:
- nitrogen oxides

Extinguishing Agents

Use the following extinguishing media when fighting fires involving this material:
- carbon dioxide - dry chemical - water spray

CONTINUED

CONTINUATION

Personal Protective Equipment

Wear self-contained breathing apparatus (pressure-demand MSHA/NIOSH approved or equivalent) and full protective gear.

SPILL OR LEAK HANDLING INFORMATION

Personal Protection

Wear gloves made of the following material:
- butyl rubber

Additional personal protective equipment should include the following:
- safety glasses (ANSI Z87.1 or approved equivalent)

Procedures

Floor may be slippery; use care to avoid falling. Transfer spilled material to suitable containers for recovery or disposal.

HAZARD INFORMATION

HEALTH EFFECTS FROM OVEREXPOSURE

Eye Contact

Material can cause the following:
- irritation

Skin Contact

Prolonged or repeated skin contact can cause the following:
- slight skin irritation

FIRE AND EXPLOSIVE PROPERTIES

Flash Point	Not Applicable
Auto-ignition Temperature	500°C/932°F Estimate
Lower Explosive Limit	Not Applicable
Upper Explosive Limit	Not Applicable

REACTIVITY INFORMATION

Instability

This material is considered stable under specified conditions of storage, shipment and/or use. See **STORAGE AND HANDLING INFORMATION** Section for specified conditions. However, avoid temperatures above 200C/392F.

CONTINUED

CONTINUATION

Hazardous Decomposition Products

Thermal decomposition may yield the following:
- divinylbenzene - styrene monomer - alkylamines - oxides of nitrogen

Hazardous Polymerization

Product will not undergo polymerization.

Incompatibility

Avoid contact with strong oxidizing agents, particularly concentrated nitric acid.

ACCIDENT PREVENTION INFORMATION

COMPONENT EXPOSURE INFORMATION

Component Information

No.		CAS REG NO.	AMT.(%)
1	Quat amine divinylbenzene/styrene copolymer, OH ion form	9017-79-2	35-50
2	Water	7732-18-5	50-65

Exposure Limit Information

Component		ROHM AND HAAS		OSHA		ACGIH	
No.	Units	TWA	STEL	TWA	STEL	TLV	STEL
1		None	None	None	None	None	None
2		None	None	None	None	None	None

PERSONAL PROTECTION MEASURES

Respiratory Protection

A respiratory protection program meeting OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. None required under normal operating conditions.

Eye Protection

Use safety glasses (ANSI Z87.1 or approved equivalent).

Hand Protection

Chemically resistant gloves should be worn whenever this material is handled.

CONTINUED

CONTINUATION

Gloves should be removed and replaced immediately if there is any indication of degradation or chemical breakthrough.

FACILITY CONTROL MEASURES

Ventilation

The ventilation system employed is dependent on the user's specific application of this material. Refer to the current edition of Industrial Ventilation: A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists for information on the design, installation, use, and maintenance of exhaust systems.

Other Protective Equipment

Facilities storing or utilizing this material should be equipped with an eyewash facility.

STORAGE AND HANDLING INFORMATION

Storage Conditions

The minimum recommended storage temperature for this material is 0C/32F. The maximum recommended storage temperature for this material is 49C/120F. Avoid repeated freeze-thaw cycles; beads may fracture.

Handling Procedures

The maximum recommended operating temperature for this material is 60C/140F. NOTE: This product as supplied is a whole bead ion exchange resin and may produce slight eye irritation. However, the ground form of this strong base anion exchange resin should be treated as a severe eye irritant. Worker exposure to ground resins can be controlled with local exhaust ventilation at the point of dust generation, or the use of suitable personal protective equipment (dust/mist air-purifying respirator and safety goggles).
Properly designed equipment is vital if these ion exchange resins are to be used in conjunction with strong oxidizing agents such as nitric acid to prevent a rapid build-up of pressure and possible explosion. Consult a source knowledgeable in the handling of these materials before preceding. Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause glass columns to shatter.

SUPPLEMENTAL INFORMATION

TYPICAL PHYSICAL PROPERTIES

State	Beads
pH	9.5-11.0
Viscosity	Not Applicable

CONTINUED

CONTINUATION

Specific Gravity (Water = 1)	1.0-1.4
Vapor Density (Air = 1)	< 1 Water
Vapor Pressure	17 mm Hg @20°C/68°F Water
Melting Point	0°C/32°F Water
Boiling Point	100°C/212°F Water
Solubility in Water	Practically insoluble
Percent Volatility	50-65 % Water
Evaporation Rate (BAc = 1)	< 1 Water

TOXICITY INFORMATION

Acute Data

No toxicity data are available for this material.

WASTE DISPOSAL

Procedure

Unused resin may be incinerated or landfilled in facilities meeting local, state, and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

REGULATORY INFORMATION

WORKPLACE CLASSIFICATIONS

This product is considered non-hazardous under the OSHA Hazard Communication Standard (29CFR 1910.1200).

This product is not a 'controlled product' under the Canadian Workplace Hazardous Materials Information System (WHMIS).

TRANSPORTATION CLASSIFICATIONS

US DOT Hazard Class . . . . . NONREGULATED

EMERGENCY PLANNING & COMMUNITY RIGHT-TO-KNOW (SARA TITLE 3)

Section 311/312 Categorizations (40CFR 370)

This product is not a hazardous chemical under 29CFR 1910.1200, and therefore is not covered by Title III of SARA.

Section 313 Information (40CFR 372)

This product does not contain a chemical which is listed in Section 313 above de minimis concentrations.

ERCLA INFORMATION (40CFR 302.4)

Releases of this material to air, land, or water are not reportable to the National Response Center under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or to state and local emergency planning committees under the Superfund Amendments and Reauthorization Act (SARA) Title III Section 304.

CRA INFORMATION

When a decision is made to discard this material as supplied, it does not meet RCRA's characteristic definition of ignitability, corrosivity, or reactivity, and is not listed in 40 CFR 261.33. The toxicity characteristic (TC), however, has not been evaluated by the Toxicity Characteristic Leaching Procedure (TCLP).

HEMICAL CONTROL LAW STATUS

All components of this product are listed or are excluded from listing on the U.S. Toxic Substances Control Act (TSCA) Chemical Substance Inventory.

ABBREVIATIONS:

ACGIH = American Conference of Governmental Industrial Hygienists
OSHA = Occupational Safety and Health Administration
TLV = Threshold Limit Value
PEL = Permissible Exposure Limit
TWA = Time Weighted Average
STEL = Short-Term Exposure Limit
BAc = Butyl acetate
Bar denotes a revision from previous MSDS in this area.

SIGMA® chemical company
THE WORLD'S FOREMOST MANUFACTURER OF RESEARCH BIOCHEMICALS AND DIAGNOSTIC REAGENTS

PHONE TOLL FREE
CONTINENTAL U.S.A. (EXCL. MO.)
1-800-325-8070
OR PHONE COLLECT
1-314-771-5766
FROM ANYWHERE IN THE WORLD
MAILING ADDRESS: P.O. BOX 14508, ST. LOUIS, MO. 63178, U.S.A.
CABLE ADDRESS: SIGMACHEM TWX: 910-761-0593

ATTN: SAFETY DIRECTOR
UMPQUA RESEARCH COMPANY
P O BOX 791
MYRTLE CREEK OR 97457

EMERGENCY PHONE 1-314-771-5765

DATE: 07/22/86

CUST#: 4-073-87920 PO#: 245

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

STOCK #: IRA-68
PRODUCT #: A7018
CAS #: 9056-59-1

NAME: AMBERLITE RESIN FREE BASE FORM GEL TYPE

TOXICITY HAZARDS

DATA NOT AVAILABLE

HEALTH HAZARD DATA

CUTE EFFECTS
MAY CAUSE EYE IRRITATION.
DUST OR PARTICLES MAY IRRITATE THE EYES AS ANY FOREIGN BODY.
IRST AID
IF SWALLOWED, WASH OUT MOUTH WITH WATER. CALL A PHYSICIAN.
IN CASE OF SKIN CONTACT, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. REMOVE CONTAMINATED CLOTHING AND SHOES AND CALL A PHYSICIAN.
IF INHALED, REMOVE TO FRESH AIR. IF BREATHING BECOMES DIFFICULT, CALL A PHYSICIAN.
IN CASE OF CONTACT WITH EYES, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. ASSURE ADEQUATE FLUSHING BY SEPARATING THE EYELIDS WITH FINGERS. CALL A PHYSICIAN.

PHYSICAL DATA

SPECIFIC GRAVITY: 1.06
SOLUBILITY: WATER-INSOLUBLE
PPEARANCE AND ODOR
OFF-WHITE BEADS, SLIGHT AMINE ODOR.

FIRE AND EXPLOSION HAZARD DATA

AUTOIGNITION TEMPERATURE: 427°C
XTINGUISHING MEDIA
CARBON DIOXIDE.
DRY CHEMICAL POWDER.
WATER SPRAY.
PECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

REACTIVITY DATA

TABILITY
STABLE.
ONDITIONS TO AVOID
TEMPERATURES ABOVE 220°C
NCOMPATIBILITIES
NITRIC ACID AND OTHER STRONG OXIDIZING AGENTS CAN FORM EXPLOSIVE TYPE REACTIONS WHEN MIXED WITH ION EXCHANGE RESINS.
AZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
ACRYLIC MONOMER, DIVINYLBENZENE

CONTINUED ON NEXT PAGE

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1-314-771-5765
FROM ANYWHERE IN THE WORLD
MAILING ADDRESS: P.O. BOX 14508, ST. LOUIS, MO. 63178, U.S.A.
CABLE ADDRESS: SIGMACHEM TWX: 910-761-0593

MATERIAL SAFETY DATA SHEET

STOCK #: IRA-68 CUST#: 4-073-87920 PO#: 245

PRODUCT #: A7018 NAME : AMBERLITE RESIN FREE BASE FORM GEL TYPE

REACTIVITY DATA

TOXIC FUMES OF:
CARBON MONOXIDE AND CARBON DIOXIDE
NITROGEN OXIDES
ZARDOUS POLYMERIZATION
WILL NOT OCCUR.

SPILL OR LEAK PROCEDURES

EPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR RESPIRATOR, CHEMICAL SAFETY GOGGLES, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
FLOOR MAY BE SLIPPERY
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
STE DISPOSAL METHOD
THIS MATERIAL MAY BE LANDFILLED AS ORDINARY TRASH.
OBSERVE ALL FEDERAL, STATE, AND LOCAL LAWS.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

OSHA/MSHA-APPROVED RESPIRATOR.
MECHANICAL EXHAUST.
COMPATIBLE CHEMICAL RESISTANT GLOVES.
CHEMICAL SAFETY GOGGLES.
DRY ION EXCHANGE RESINS EXPAND WHEN WETTED, WHICH MAY CAUSE COLUMN TO SHATTER.

FFICES AT: SIGMA LONDON CHEM CO LTD
FANCY ROAD, POOLE
DORSET BH17 7NH
ENGLAND

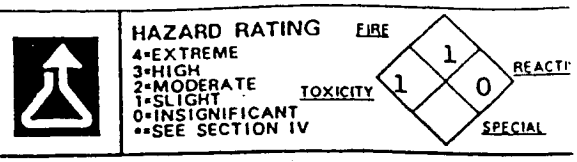
SIGMA CHEMIE GmbH MUNCHEN
A M BAHNHOFEIG 7
D-8019 TAUFKIRCHEN
WEST GERMANY

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
*=SEE SECTION IV



BS242
LIST 7

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS
NOT WHMIS CONTROLLED

MATERIAL	CODE	KEY	DOT HAZARD CLASS
AMBERLITE® IRN-150 Resin	69855	891090-3	NON-REGULATED
	DATE ISSUED 11/08/88		

FORMULA	CHEMICAL NAME OR SYNONYMS
Not applicable	Mixed bed ion exchange resin (hydrogen and hydroxide forms)

I – COMPOSITIONAL INFORMATION

	CAS Reg. No.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Anion/cation exchange resin	NONHAZ	35-50	NE	NE	NE
Water	NONHAZ	50-65	NE	NE	NE

NE = None established

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH.			VISCOSITY
Beads; pH (aqueous slurry) = 5 to 9			NA
MELTING OR FREEZING POINT	**BOILING POINT**	**VAPOR PRESSURE (mm Hg)**	**VAPOR DENSITY (AIR=1)**
0C/32F (water)	100C/212F (water)	17 @20C (water)	Less than 1 (water)
SOLUBILITY IN WATER	**PERCENT VOLATILE (BY WEIGHT)**	**SPECIFIC GRAVITY (WATER=1)**	**EVAPORATION RATE (BUTYL ACETATE=1)**
Negligible	50-65 (water)	1.1-1.3	Less than 1 (water)

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
NA	500C/932F (est.)	NA	NA

EXTINGUISHING MEDIA

☐ FOAM ☐ "ALCOHOL" FOAM ☒ CO_2 ☒ DRY CHEMICAL ☒ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent) and full protective gear.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Toxic combustion products may include alkylamines and oxides of sulfur and nitrogen.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

STEL = None established.

EFFECTS OF OVEREXPOSURE

Eye Contact: Product can cause eye irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: Immediately flush eyes with large amounts of water and continue for at least 15 minutes. Get prompt medical attention.

FORM SPMS REV. 11/87

URC 80279

V – REACTIVITY INFORMATION

STABILITY	CONDITIONS TO AVOID
[X] STABLE [ ] UNSTABLE	Temperatures over 200C/392F.

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may yield styrene monomer, divinylbenzene, alkylamines and oxides of sulfur and nitrogen.

HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
[ ] MAY OCCUR [X] WILL NOT OCCUR	None known

INCOMPATIBILITY (MATERIALS TO AVOID): [ ] WATER [X] OTHER — Avoid contact with concentrated nitric acid or any other strong oxidizing agent at all times.

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Floor may be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.

WASTE DISPOSAL METHODS: Unused resin may be incinerated or landfilled in facilities meeting local, state and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE

Normal room ventilation.

RESPIRATORY PROTECTION

None required for normal operations.

PROTECTIVE GLOVES	EYE PROTECTION
None required	Safety glasses (ANSI Z-87.1 or approved equivalent)

OTHER PROTECTIVE EQUIPMENT

Eyewash facility

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 49C/120F MIN. 0C/32F	YES	NO	NO	YES

NOTE: Store at ambient temperatures. Avoid repeated freeze-thaw cycles.

NOTE: Ground ion exchange resins should be treated as potential eye irritants. A finely ground form of a structurally related strong acid cation exchange resin produced severe rabbit eye irritation.

NOTE: The maximum operating temperature for this product is 60C/140F. Functional group destruction and loss of capacity will occur above this temperature.

IX – TOXICITY INFORMATION

No toxicity data available for this product.

X – MISCELLANEOUS INFORMATION

Caution: Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause a glass column to shatter.

Caution: Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent rapid build-up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange beads, consult sources knowledgeable in handling these materials.

NA = NOT APPLICABLE C = CEILING VALUE	KEY	DATE OF ISSUE	SUPERSEDES
	891090-3	11/08/88	09/04/87

APPENDIX E

Document #: 80277
Revision: ____
Date Released: 4-28-92

PRETREATMENT UNIBED

SIZING CALCULATIONS FOR THE

CATALYTIC OXIDATION SYSTEM

WITH A PRETREATED UMIDITY CONDENSATE

FOR THE

NASA-MSFC PHASE II SBIR:

CATALYTIC METHODS USING MOLECULAR

OXYGEN FOR TREATMENT OF PMMS AND

ECLSS WASTE STREAMS

Prepared By: _____

Approved By: _____ **Date:** 4-28-92

Approved By: _____ **Date:** 4-28-92

URC 80277

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

1.0 INTRODUCTION

This document presents the design for the catalytic oxidation system's Pretreatment Unibed. The feed solution being treated is an ersatz humidity condensate. (see Table 1) The Pretreatment Unibed is designed to remove inorganic cations and anions by ion exchange. The high concentration of ammonium ion in the influent is detremental to the performance of the catalytic oxidation process. In addition, organic acids are also removed by this Unibed. This Unibed will be installed up stream of the catalytic oxidation system, prior to the deiodination bed. (see Figure 1)

1.1 Applicable Document

1.1.1 SBIR Phase II Contract NAS8-38490

1.2 Applicable Drawings

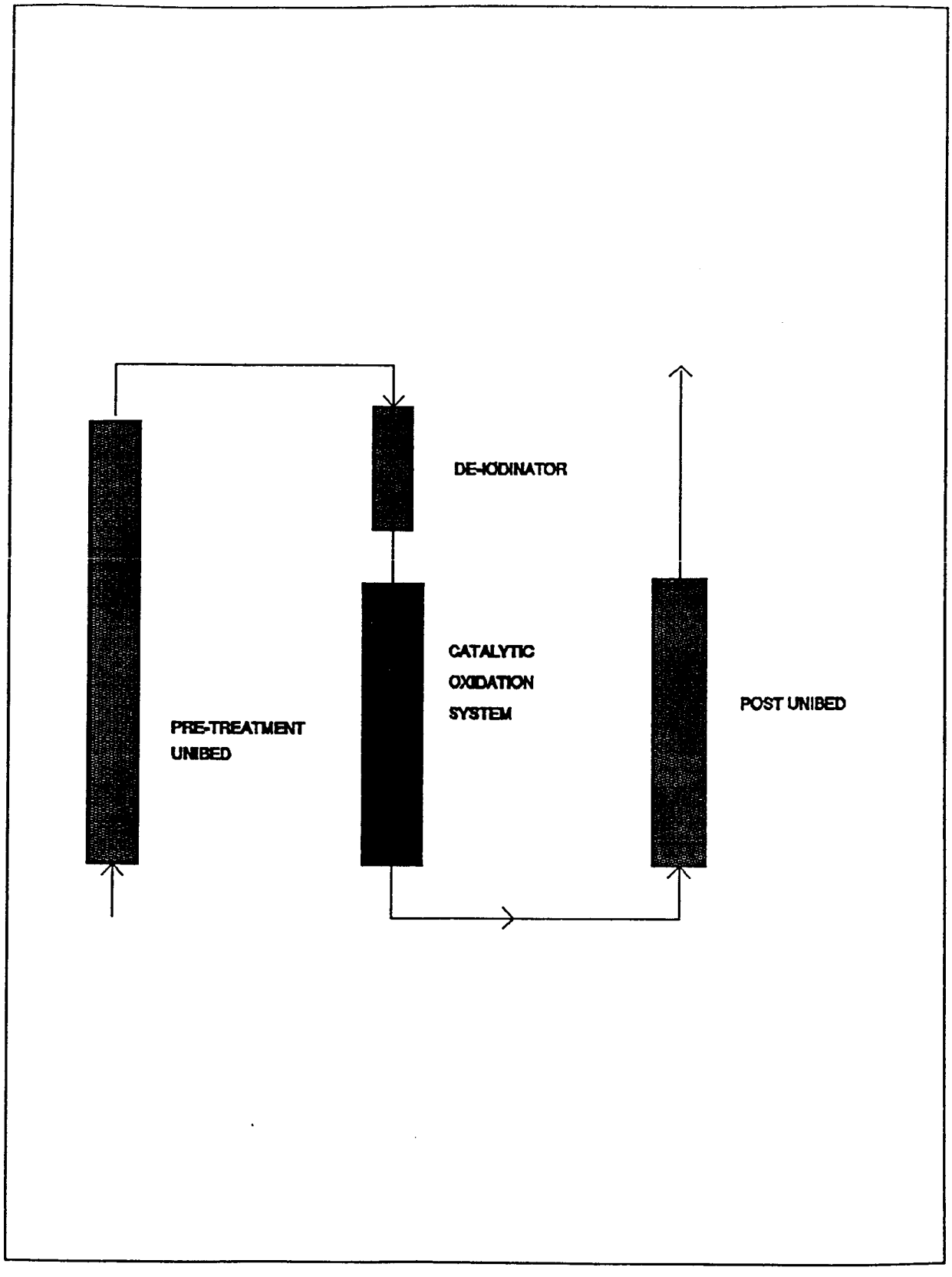
1.2.1 Umpqua Research: URC DWG 90208

1.3 General Approach

The design is based on (1) isotherm data from shaker table and small column single contaminant, single media tests performed at Umpqua under the following NASA contracts: NAS9-17073, NAS9-17464, NAS9-17523, and NAS9-17611 and (2) manufacturer's stated ion exchange capacity.

FIGURE 1

BED LOCATION



2.0 DESIGN REQUIREMENTS

2.1 Configuration

2.1.1 One 24 in long, 2 in diameter stainless steel tube with inner teflon coating and 1/8 " pipe thread elbows at the inlet.

2.2 Life at Design Conditions

2.2.1 Throughput: 648 L

2.2.2 Time: 45 days

2.3 Inlet Solution

2.3.1 Humidity Condensate (Table 1)

2.4 Flow

2.4.1 Flow Rate: 10 mL/min ≈ 0.6 L/hr

2.4.2 Daily Operating Time: 24 hr/day

2.4.3 1-Day Throughput: 14.4 L

2.5 Temperature

2.5.1 Operating Range: 68 - 77 F

2.6 Pressure

2.6.1 Maximum Operating Pressure (MOP): 40 psig

2.6.2 Proof Pressure: 60 ± 5 psig

2.7 Pressure Drop

2.7.1 Maximum Allowable Pressure Drop: 5 psig

2.8 Iodine Output

2.7.1 Range: 0.5 - 4.0 ppm

2.9 Outlet Quality

2.9.1 Requirements: See Table 2.

Table 1

ERSATZ HUMIDITY CONDENSATE

Organics

	mg/liter	TOC (mg/liter)
Caprylic Acid	0.537	0.358
Dibutylamine	7.28	5.412
Dimethyl Phthalate	0.548	0.339
Ethanol	14.00	7.300
Formic Acid	1.65	0.431
Isopropanol	0.87	0.522
Lactic Acid	0.93	0.372
Methanol	1.54	0.577
Propanoic Acid	0.871	0.424
Thiourea	14.56	2.298
	42.79 mg/liter	18.03 mg/liter

Inorganics

Ammonium Hydroxide	36.3
Ammonium Phosphate	0.53
Ammonium Sulphate	0.25
Calcium Chloride	0.15
Sodium Chloride	0.36
Sodium Fluoride	0.49
Sodium Nitrate	0.36
	38.44 mg/liter

TABLE 2

PRETREATMENT UNIBED SORBENTS

CONTAMINANT	CONCENTRATION meq/cm³	MEDIA	MFG CAPACITY meq/Cm³(mg/cm³)	4RC DESIGN CAPACITY mg/Cm³	SWELLING
Ammonia	1.05	IRN77 IRN 150	1.7 (30.6) 0.8	32	-5
Calcium	0.0027	IRN 77	1.7 (68.1)	68.1	-5
Sodium	0.0221	IRN 77	1.7 (39.1)	39.1	-5
Chloride	0.0089	IRN 78	1.2 (60.3)	60.3	-30
Fluoride	0.0117	IRN 78	1.2 (32.3)	32.2	-30
Hydrogen Phosphate	0.0080	IRN 78	1.2 (81.6)	81.6	-30
Sulfate	0.0038	IRN 78	1.2 (81.6)	81.6	-30
Nitrate	0.0042	IRN 78	1.2 (105.4)	105.4	-30
Caprylic Acid	0.0037	IRA 68	1.6 (230.7)	7.3	+20
Formic Acid	0.0359	IRA 68	1.6 (73.6)	5	+20
Lactic Acid	0.0103	IRA 68	1.6 (144.1)	3.1	+20
Propanoic Acid	0.0118	IRA 68	1.6 (118.5)	5.6	+20

TABLE 3
PRETREATMENT UNIBED MEDIA CONFIGURATION

FLOW DIRECTION	SORBENT	REFERENCE PARAGRAPH	VOLUME (Cm^2)	FUNCTION
↓	MCV RT	4.2.1	60	Microbial Control
	IRN 77	4.2.2	380	Remove NH_4^+ Ca^{2+}, and Na^+
	IRN 150	4.2.3	60	Remove NH_4^+ Ca^{2+}, and Na^+
				Remove Cl^-, F^- $HPO_4^=$ & NO_3^-
	IRA 68	4.2.4	577	Remove Organic Acids
	MCV RT	4.2.1	60	Microbial Control

3.0 DESIGN DATA

The design data were developed by UMPQUA under contract to NASA-JSC for the ion exchange and MCV media (see paragraph 1.3 for applicable contract numbers).

3.1 Sorbent Selection

The best performing media have been selected for each bed, based on single adsorbent-single contaminant/shaker table and single adsorbent-single contaminant/dynamic column tests run previously by UMPQUA. The selected adsorbents are listed in Table 2.

3.2 Adsorption Equilibrium Data

Table 2 also contains ion exchange loadings (equilibrium data) necessary for the design of the sorption sub-beds. These data are from UMPQUA small-column tests and are lower than the manufacturer's published values.

4.0 UNIBED DESIGN

4.1 Unibed Dimensions

Each unibed consists of a single 2 in x 24 in long stainless steel housing containing nominally, 1117 cc of media. The total bed length is 22 in. A sub-bed volume of 60 cc provides the minimum bed length to diameter ratio necessary to insure proper sub-bed performance. The remaining volume is occupied by lip seals, an internal spring and the end caps.

4.2 Unibed Configuration and Sub-bed Sizing

The configuration of the Pretreatment Unibed is shown in Table 3. The initial MCV-RT resin sub-bed maintains the sterile integrity of the unibed. The IRN 77 sub-bed removes cations such as ammonium, calcium, and sodium ions. The third sub-bed, IRN- 150, is a mixed cation and anion exchange resin which is primarily designed to remove chloride, fluoride, sulfate, nitrate, and hydrogen phosphate anions as well as the cations mentioned above. The next sub-bed consists of IRA 68, a weak base anion exchange resin, which effectively removes organic acids such as caprylic, formic, lactic,

and propanoic acid. The final MCV-RT resin sub-bed imparts 1-4 ppm idodine into the effluent stream for microbial control. The pretreatment Unibed is designed to remove all moderately sorbable species from ersatz humidity condensate. No provision is made for removal of alcohols, thiourea, dimethyl phthalate, or dibutylamine. These species will be oxidized by catalytic oxidation. The sizing rational for each sub-bed is presented in the following paragraphs.

4.2.1 MCV-RT

MCV-RT resin is required at both the entrance and exit of the pretreatment Unibed for microbial control. The minimum volume due to L/D constraints is 60 cm^3. The resin imparts 1-4 ppm of I_2 for a duration of 50 liters/cm^3 of media. The life of these sub-beds are:

Life: 60 cm^3 X 50 liters/cm^3 /14.4 liters/day = 208 days

4.2.2 IRN 77

Cations are removed by IRN 77, a strongly acidic cation exchange resin prepared by UMPQUA in the H^+ form. These include calcium, sodium, and ammonium ions. Their concentration in the stream are given by:

NH_4^+ = 1.05 meq/liter, Ca^{2+} = 0.0027 meq/liter, and Na^+ = 0.0221 meq/liter

$NH_4^+ + Ca^{2+} + Na^+$ = 1.075 meq/liter

The 380 cm^3 sub-bed if IRN 77 will hold 1.7 mge/cm^3:

Total sorption capacity : 380 cm^3 x 1.7 meq/cm^3 = 646 meq

Throughput capacity: 646 meq + 1.075 meq/liter = 601 liter

Life: 601 liters + 14.4 liters/day = 42 days

4.2.3 IRN 150

Both cations and anions are removed by IRN 150 which contains 38% volume of IRN 77 and 62% of IRN 78. The total bed volume is 60 cm^3.

Total Sorption Capacity: 60 cm^3 x 0.8 meq/cm^3 = 48 meq

For cations: 48 meq ÷ 1.075 meq/liter = 44.65 liters

Life: 44.65 liters ÷ 14.4 liters/day = 3.1 days

For anions: 0.00886 meq/liter of Cl^-, 0.00801 meq/liter of $HPO_4^=$, 0.00378 meq/liter of $SO_4^=$, 0.00423 meq/liter of NO_3^-, and 0.0117 meq/liter of F^- = 0.0366 meq/liter

Total Anions: 48 meq ÷ 0.0366 meq/liter = 1312 liters

Life: 1312 liters ÷ 14.4 liters/day = 91 days

4.2.4 TRA-68 anions are removed by this weakly basic anion exchange resin. In particular, weak organic acids such as caprylic, formic, lactic, and propanoic sorb well on this resin. These contaminants are present in ersatz humidity condensate and are given by:

Caprylic Acid = 0.537 mg/liter, Formic Acid = 1.65 mg/liter

Lactic Acid = 0.93 mg/liter, and propanoic Acid = 0.871 mg/liter

Total various sorption capacities are 7.3 mg/cm^3 for caprylic, 5 mg/liter for formic, 3.1 mg/liter for lactic, and 5.6 mg/liter for propanoic.

For a life of 45 days or 648 liters the bed size

648 liters (0.537 mg/liter) ÷ 7.3 mg/cm^3 = 47.7 cm^3

648 liters (1.657 mg/liter) ÷ 5 mg/cm^3 = 213.8 cm^3

648 liters (0.93 mg/liter) ÷ 3.1 mg/cm^3 = 194.4 cm^3

648 liters (0.871 mg/liter) + 5.6 mg/cm^3 = 100.8 cm^3

TOTAL = 557 cm^3

4.2.5 MCV-RT

Life: 60 cm^3 x 50 liters/cm^3 + 14.4 liters/day = 208 days

4.2.6 Sizing Discussion

The design summarized in Table 3 was obtained within the dimension restraints in Paragraph 4.1. The capacity is limited by the overall bed size. The limiting factor in the bed life is the IRA 68 sub-bed which sorbs organic acids. Consequently, the Pretreatment Unibed expected life is 45 days.

4.3 Pressure Drop

Previous testing developed a pressure drop equation.

$\delta P = 0.4\ WL\ \mu/D2$

Where:

δP = pressure drop, psi

W = Flow rate, lb/min

L = bed length, in

D = bed diameter, in

μ = viscosity, centipoise

For the pretreatment Unibed

W = 1.32 lb/hr = 0.022 lb/min

L = 22 in

D = 2 in

μ = 1 centipoise

$$\delta P = 0.4(0.022)(22)(1)/(2)^2 = 0.05 \text{ psi}$$

Specified max $\delta P = 5.0$ psi

4.4 Summary of Unibed Design Values

A summary of the design values for the beds is given in Table 4.

TABLE 4. SUMMARY OF POST UNIBED DESIGN VALUES

Parameter	Value
URC Drawing Number	90207
Nominal ID	2 in
Water System	Potable
Flow Rate	1.32 lb/hr (0.6 L/hr)
Daily Operating Time	24 hr/day
Thruput, 1 day	14.4 L
Total Media Volume	661cc
Cross Sectional Area	20.3 cm^2
Total Length of Media (Installed)	12.84 in
Face Velocity	0.493 cm/min
Empty Bed Contact Time	66.1 min
Life (limited by IRA 68) -	720 L
-	50 days

APPENDIX I

MEDIA INFORMATION

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE® IRN-77

ION EXCHANGE RESIN

Amberlite IRN-77 is a strongly acidic gelular polystyrene cation exchange resin supplied in the hydrogen form. This resin is Nuclear Grade and processed to the highest purity standards to meet the stringent requirements of the Nuclear Industry. Amberlite IRN-77 contains a minimum of 99% of its exchange sites in the hydrogen form.

The manufacturing process for this resin is controlled to keep inorganic impurities at the lowest possible levels. Special treatment procedures are also used to remove traces of soluble organic compounds. These high standards of resin purity will help keep nuclear systems free of contaminants and deposits, and prevent increases in radioactivity levels due to activation of impurities in the reactor core.

IMPORTANT FEATURES OF AMBERLITE IRN-77 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-77 resin exhibits a minimum capacity of 1.8 meq/ml.

EXCEPTIONAL PURITY: Amberlite IRN-77 resin is manufactured to demanding purity specifications which assure a minimum of ionic and nonionic contamination.

GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-77 resin offers excellent performance with respect to particle break down from attrition or osmotic shock.

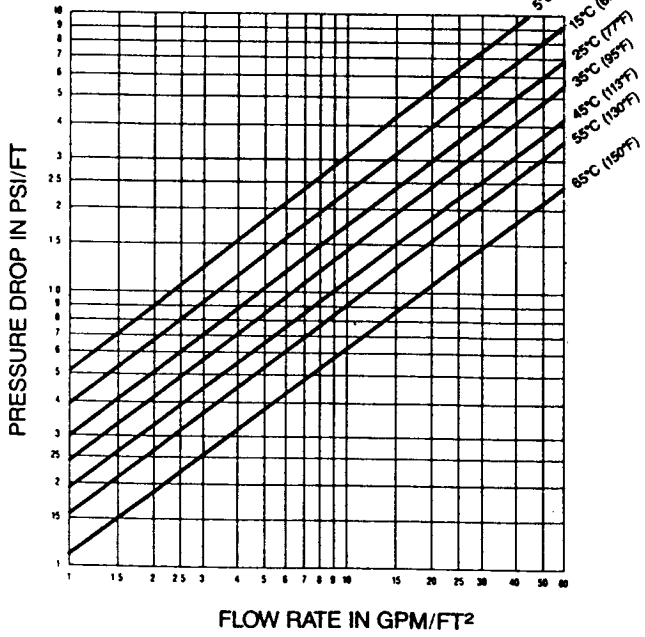
INSOLUBLE IN ALL COMMON SOLVENTS

HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-77 resin in normal downflow operation at various temperatures and flow rates is shown in the graphs below (data based on backwashed and classified resin bed).

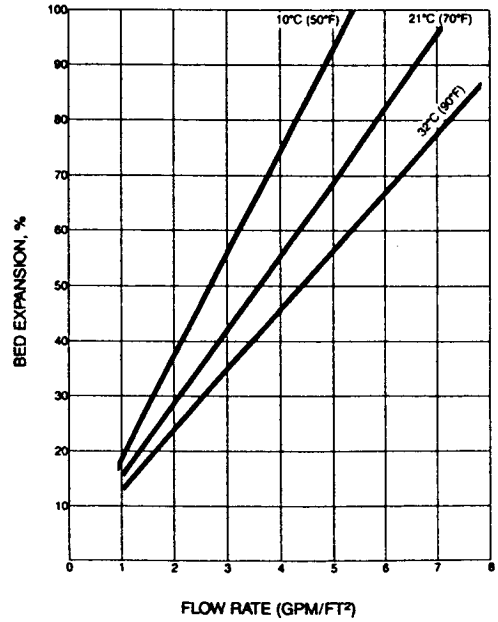
RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. If the resin requires backwashing the bed should be expanded a minimum of 50%.

AMBERLITE® IRN-77 RESIN
PRESSURE DROP



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² × 2.45
PSI/ft to MH_2O/M resin = PSI/ft × 2.30

AMBERLITE® IRN-77 RESIN
HYDRAULIC EXPANSION



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² × 2.45

RECOMMENDED CONDITIONS OF OPERATION

ED DEPTH:	24" minimum (0.61m)
PERATING TEMPERATURE:	250°F maximum (121°C)
ERVICE FLOW RATE:	1–5 gpm/ft³ (8.0 to 40.1 l/hr/l)

CHEMICAL CHARACTERISTICS

NIC FORM:	Hydrogen
OTAL EXCHANGE CAPACITY:	1.8 meq/ml minimum
OISTURE CONTENT:	55% maximum
NIC CONTENT:	
quivalent % H, minimum	99
ETALS CONTENT:	
Sodium, (ppm dry resin) maximum	50
Iron, (ppm dry resin) maximum	50
Copper, (ppm dry resin) maximum	10
Heavy Metals as Pb, (ppm dry resin) maximum	10
Aluminum, (ppm dry resin) maximum	50
Calcium, (ppm dry resin) maximum	50
Magnesium, (ppm dry resin) maximum	50

PHYSICAL CHARACTERISTICS

HAPE:	Spherical beads
IPPING WEIGHT:	50 lbs/ft³ (800g/l)
RTICLE SIZE (U.S. MESH):	
reen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5
ATILLON:	
g., gm/bead minimum	350
200 gm/bead minimum	95
RFECT BEADS:	95% minimum
LUBILITY:	0.10% maximum

APPLICATIONS

PRIMARY WATER TREATMENT: Amberlite IRN-77 resin is very effective in removing fission products, activated corrosion products, suspended matter and Lithium 7 from reactor coolant streams.

RAD WASTE TREATMENT: Amberlite IRN-77 resin is very effective in removing radioactive cations such as Cesium 137 from waste streams.

DECONTAMINATION: Amberlite IRN-77 resin removes cationic radioactive material from spent decontaminating solutions.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-77 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

January 1986

Printed in U.S.A.

OHM AND HAAS COMPANY
HILADELPHIA, PENNSYLVANIA 19105
ID PROCESS CHEMICALS

AMBERLITE® IRA-68

Amberlite IRA-68 is a gel type, weakly basic anion exchange resin possessing tertiary amine functionality in a crosslinked acrylic matrix. In addition to exhibiting a high exchange capacity, this resin has good chemical and thermal stability and is especially suited to the adsorption and desorption of organic materials from solution. Amberlite IRA-68 is also well suited for applications in the pharmaceutical, chemical and food processing industries for the neutralization of strong acids and other special processes.

IMPORTANT FEATURES OF AMBERLITE IRA-68

HIGH CAPACITY AND LOW COST REGENERATION—Amberlite IRA-68 has an operating acid removal exchange capacity of 29 kgrs/ft³ (66.4 g/l as $CaCO_3$) of resin. Regeneration is accomplished using 110-120% of the quantity of base chemically equivalent to the operating capacity. Thus, regenerant costs are significantly lower than for strongly basic resins and waste problems are held at a minimum.

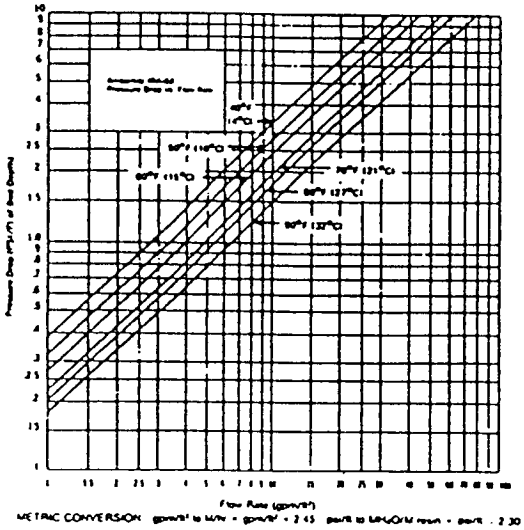
RESISTANCE TO ORGANIC FOULING—Amberlite IRA-68 is synthesized with an open structure which permits the effective adsorption and desorption of large organic molecules. Because of this open structure, organic materials are readily eluted from Amberlite IRA-68 resulting in no capacity loss due to organic fouling.

CHEMICAL FORM—Amberlite IRA-68 is shipped in the fully regenerated free-base form and can be utilized immediately for acid removal.

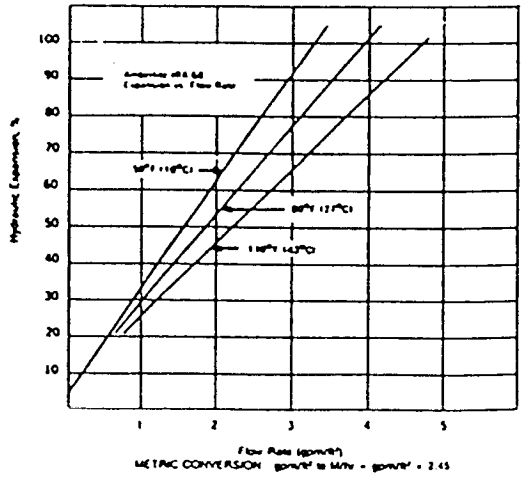
INSOLUBLE IN ALL COMMON SOLVENTS.

HYDRAULIC CHARACTERISTICS

PRESSURE DROP—The curves show the expected pressure drop per foot of bed depth in normal downflow operation at various temperatures as a function of flow rate.



BACKWASH CHARACTERISTICS—After each operational cycle Amberlite IRA-68 should be backwashed for approximately ten minutes to re-classify the resin particles and purge the bed of any insoluble material which may have collected on top of the resin. The resin bed should be expanded a minimum to 50% during backwash.



PHYSICAL CHARACTERISTICS

PHYSICAL FORM—Uniform, spherical particles shipped in moist, fully regenerated condition.

DENSITY—41 to 47 lbs/ft³ (656 to 752 g/l)

SHIPPING WEIGHT—45 lbs/ft³ (720 g/l)

MOISTURE CONTENT—60% as shipped *

SCREEN GRADING (WET)—16 to 50 mesh (U.S. Standard Screen)

EFFECTIVE SIZE—0.45 mm.*

FINES CONTENT—3% maximum

SWELLING—20%* upon complete conversion of the resin from the free base to the chloride form.

*Approximate

SUGGESTED OPERATING CONDITIONS

.imitation — 0 to 7
imum Temperature — 140°F (60°C)
imum Bed Depth — 24 inches (0.61 m)
:wash Flow Rate — See detailed information
:nerant Concentration* —4%
:nerant Flow Rate — 0.5 to 1.0 gpm/ft³ (4.0 to 8.0 l/hr/l)
:neration Level — See detailed information
Flow Rate — 0.5 gpm/ft³ (4.0 l/hr/l) initially, to displace regenerant then 1.5 gpm/ft³ (12.0 l/hr/l)
e Water Requirements — 50 to 75 gal/ft³ (6.7 to 10.1 l/l)
ice Flow Rate — 1 to 3 gpm/ft³ (8.0 to 24.1 l/hr/l)
ıange Capacity — See detailed information
Safe Handling Information section

REGENERATION LEVEL AND CAPACITY

ıinimum acid removal operating capacity of 28 kgrs. (as o_3/ft³) (64 g/l) of resin may be expected using the follow· amounts of regenerants:
3.7 lbs of NaOH/ft³ (59.2 g/l) or
3.2 lbs of NH_4OH/ft³ (51.2 g/l) or
4.9 lbs of Na_2Co_3/ft³ (78.4 g/l)

APPLICATIONS

NIZATION — The marked worldwide increase in the use of lic anion exchange resins is illustrated by the increased zation of Amberlite IRA-458 as the strongly basic anion ıange component of many deionization systems. Amberlite .-458 is installed when high capacity, excellent organic ing resistance, and good physical stability are required. 'here plant design, however, dictates the use of a weakly c anion exchange resin with properties comparable to those ımberlite IRA-458, Amberlite IRA-68 is the prime choice. mberlite IRA-68 is a gelular acryic weakly basic anion ıange resin with tertiary amine functionality. The acrylic rix of Amberlite IRA-68 is hydrophilic making it similar to : of Amberlite IRA-458. When compared with gelular poly- ene or epoxy-amine type resins, the acrylic matrix of berlite IRA-68 shows superior kinetic behavior particularly regeneration elution of organics. This superior organic foul- resistance places Amberlite IRA-68 in the same class as croreticular styrene weakly base anion exchange resins. 'he flexible nature of the gelular acrylic matrix imparts ex- ent physical stability with regard to mechanical attrition, osmotic shock. This, again, is normally attributed to a croreticular structure.

n contrast to most weakly basic anion exchange resins, the king capacity of Amberlite IRA-68 is independent of service v rate (1.0 to 5.0 gpm/ft³ [8.0 to 40.1 l/hr/l]), temperature °-70°F [4 to 21°C]), and only slightly affected by influent ter analysis changes. A base working capacity of 29.0 kgr/ft³ .4 g/l) can be expected under normal operating conditions.

The weakly basic anion exchange resin Amberlite IRA-68 incorporates the high working capacity of gel styrene and gel epoxy-amine weakly basic anion exchange resins, without the latter resins' inherent physical weaknesses and organic fouling tendencies. At the same time, it also incorporates the superior physical stability and organic fouling resistance associated with macroreticular weakly basic anion exchange resins, while avoiding the lower working capacities normally associated with macroreticular structure.

ACID MINE DRAINAGE — A modification of the DESAL Process for the treatment of acid mine drainage water has been developed in the Rohm and Haas laboratories. This process, utilizing Amberlite IRA-68 operating in the bicarbonate cycle, converts metallic sulfates, the principal anionic constituents of AMD waters, into soluble bicarbonates which when aerated precipitate as insoluble hydrous oxides. The resulting effluent water will contain calcium and magnesium hardness, which if desired, can be softened using a cold lime softening treatment.

DEIONIZATION AND ORGANIC SCAVENGING — Amberlite IRA-68 is particularly suited for the removal of strong acids and the deionization of process liquors. This resin should be considered for use in the deionization of water and special applications where high molecular weight materials are to be removed from solution.

DIASHING AND DECOLORING CORN SUGAR — When properly pretreated Amberlite IRA-68 is cleared for use in food processing under FDA Food Additive Regulation 21CFR-173.25. According to this regulation the food or aqueous flow must be maintained at 50°C or below, and the flow through the resin must be less than 0.5 gpm/ft³ (4.0 l/hr/l).

SAFE HANDLING INFORMATION — A Material Safety Data Sheet is available for Amberlite IRA-68. To obtain a copy contact your Rohm and Haas representative.

Caution: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

IE-120-67/80 June 1982 Printed in U.S.A.

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE® IRN-150

ION EXCHANGE RESIN

Amberlite IRN-150 is a mixture of gelular, polystyrene cation and anion exchange resins. Amberlite IRN-150 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation (Amberlite IRN-77) and the strongly basic anion (Amberlite IRN-78) exchange resins. It is supplied in the hydrogen/hydroxide form as clear, amber colored spherical particles virtually perfect in bead appearance. Amberlite IRN-150 resin is designed for use in industrial water treatment applications, particularly in once through applications such as primary water chemistry control in nuclear power operations. This resin combines the properties of high capacity and excellent resistance to bead fracture from attrition or osmotic shock.

Amberlite IRN-150 resin is designated as a Nuclear Grade resin and is manufactured using special processing procedures. These procedures, combined with a patented Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry. Amberlite IRN-150 resin is recommended in any non-regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non-ionic contamination.

IMPORTANT FEATURES OF AMBERLITE IRN-150 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-150 resin will exhibit a nominal operating capacity of 12 kg/ft³ (0.55 meq/ml).

EXCEPTIONAL PURITY: Amberlite IRN-150 resin is manufactured to demanding purity specifications which assure a minimum of ionic and non-ionic contamination.

GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-150 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

RECOMMENDED CONDITIONS OF OPERATION

The recommended conditions for operation of Amberlite IRN-150 resin are listed below.

BED DEPTH:	24" minimum (0.61 m)
SERVICE FLOW RATE:	2–5 gpm/ft³ (16 to 40.1 l/hr/l)

PHYSICAL CHARACTERISTICS

SHAPE:	Spherical beads
SHIPPING WEIGHT:	43 lbs/ft³ (688 g/l)

PARTICLE SIZE (U.S. MESH):

Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5

PERFECT BEADS: 95% minimum

CHEMICAL CHARACTERISTICS

IONIC FORM:	Hydrogen/Hydroxide
CATION TO ANION EQUIVALENT RATIO:	1:1

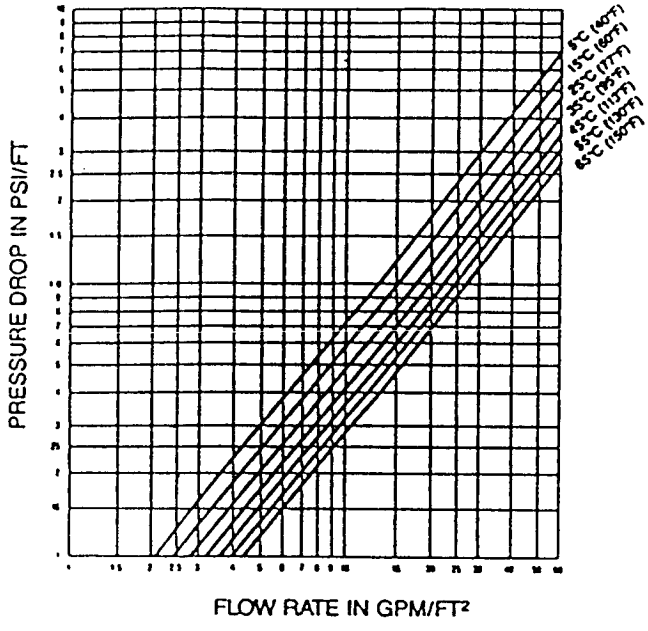
Ionic Content by Individual Component:	IRN-77	IRN-78
Equivalent % H, minimum	99.0	na
Equivalent % OH, minimum	na	95.0
Equivalent % Cl, maximum	na	0.10
Equivalent % CO_3, maximum	na	5.0
Equivalent % SO_4, maximum	na	0.10
Sodium (ppm dry resin) maximum	50	50
Iron (ppm dry resin) maximum	50	50
Copper (ppm dry resin) maximum	10	10
Heavy metals as Pb (ppm dry resin) maximum	10	10
Aluminum (ppm dry resin) maximum	50	50
Calcium (ppm dry resin) maximum	50	50
Magnesium (ppm dry resin) maximum	50	50

HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of bed depth of Amberlite IRN-150 resin in normal down flow operation at various temperatures and flow rates is shown in the graph below.

RESIN HANDLING: To retain the high purity standards of nuclear grade resins, deionized water should be used for all resin handling. Contact of the resin with air should also be minimized to avoid CO_2 pickup and subsequent loss of capacity of the anion resin.

AMBERLITE® IRN-150 RESIN
PRESSURE DROP



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45
PSI/ft to MH₂O/M resin = PSI/ft x 2.30

APPLICATIONS

MIXED BED DEIONIZATION: The physical and chemical characteristics of Amberlite IRN-150 resin provide excellent performance when used in production of high quality water in any mixed bed deionization application.

NUCLEAR APPLICATIONS: The purity and physical stability of Amberlite IRN-150 resin provides unsurpassed performance in nuclear applications such as chemistry control in primary water treatment. Amberlite IRN-150 resin can also be used for a variety of rad waste applications.

PRODUCTION OF ULTRA PURE WATER: Amberlite IRN-150 resin is an excellent choice for once through (non-regenerable) applications typically found in the final DI water processing for the semiconductor industry. Amberlite IRN-150 resin provides rapid rinse to 18 megohm, high capacity, and reliable production of the highest-quality water.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-150 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

APPENDIX II

MATERIAL SAFETY DATA SHEETS (MSDS)

UMPQUA RESEARCH COMPANY

P.O. BOX 791 - 626 N.E. DIVISION
MYRTLE CREEK, OREGON 97457
(503) 863-5201
FAX (503) 863-6199

MATERIAL SAFETY DATA SHEET

Feb. 20, 1991

--------IDENTIFICATION--------

PRODUCT #: 90021-47 NAME: MCV-RT Iodinated Resin

----------REACTIVITY DATA----------

Drying results in release of iodine vapor.
Stability: stable.
Conditions to avoid: Temperatures over 220 C.

Incompatibilities: Nitric Acid and other strong Oxidizing agents can cause explosion.
Materials to avoid: NH_3, Acetylene, Acetaldehyde, Active metals particularly powdered Al.
Reactions when mixed with ion exchange resins.
Hazardous combustion or decomposition products.
Styrene Monomer, Divinylbenzene
Toxic fumes of:
Carbon Monoxide and Carbon Dioxide
Nitrogen Oxides
Hazardous Polymerization
Will not occur.

----------SPILL OR LEAK PROCEDURES----------

Steps to be taken if material is released or spilled:
Wear respirator, chemical safety goggles, rubber boots and heavy rubber gloves.
Sweep up, place in a bag and hold for waste disposal.
Floor may be slippery.
Avoid raising dust.
Ventilate area and wash spill site after material pickup is complete.
Waste Disposal Method:
This material may be landfilled as ordinary trash.
Observe all Federal, State, and Local Laws.

---------PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE---------

OSHA/MSHA - approved respirator.
Mechanical exhaust.
Compatible Chemical resistant gloves.
Dry ion exchange resins expand when wetted, which may cause column to shatter.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. UMPQUA RESEARCH COMPANY SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT.

SIGMA® chemical company
THE WORLD'S FOREMOST MANUFACTURER OF RESEARCH BIOCHEMICALS AND DIAGNOSTIC REAGENTS

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FROM ANYWHERE IN THE WORLD
MAILING ADDRESS: P.O. BOX 14508, ST. LOUIS, MO. 63178, U.S.A.
CABLE ADDRESS: SIGMACHEM TWX: 910-761-0593

ATTN: SAFETY DIRECTOR
UMPQUA RESEARCH COMPANY
P O BOX 791
MYRTLE CREEK OR 97457

EMERGENCY PHONE 1-314-771-5765

DATE: 07/22/86

CUST#: 4-073-87920 PO#: 245

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

STOCK #: IRA-68
PRODUCT #: A7018
CAS #: 9056-59-1

NAME: AMBERLITE RESIN FREE BASE FORM GEL TYPE

TOXICITY HAZARDS

DATA NOT AVAILABLE

HEALTH HAZARD DATA

CUTE EFFECTS
MAY CAUSE EYE IRRITATION.
DUST OR PARTICLES MAY IRRITATE THE EYES AS ANY FOREIGN BODY.

IRST AID
IF SWALLOWED, WASH OUT MOUTH WITH WATER. CALL A PHYSICIAN.
IN CASE OF SKIN CONTACT, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. REMOVE CONTAMINATED CLOTHING AND SHOES AND CALL A PHYSICIAN.
IF INHALED, REMOVE TO FRESH AIR. IF BREATHING BECOMES DIFFICULT, CALL A PHYSICIAN.
IN CASE OF CONTACT WITH EYES, FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. ASSURE ADEQUATE FLUSHING BY SEPARATING THE EYELIDS WITH FINGERS. CALL A PHYSICIAN.

PHYSICAL DATA

SPECIFIC GRAVITY: 1.06
SOLUBILITY: WATER-INSOLUBLE

PPEARANCE AND ODOR
OFF-WHITE BEADS, SLIGHT AMINE ODOR.

FIRE AND EXPLOSION HAZARD DATA

AUTOIGNITION TEMPERATURE: 427°C

CTINGUISHING MEDIA
CARBON DIOXIDE.
DRY CHEMICAL POWDER.
WATER SPRAY.

PECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

REACTIVITY DATA

TABILITY
STABLE.

ONDITIONS TO AVOID
TEMPERATURES ABOVE 220°C

NCOMPATIBILITIES
NITRIC ACID AND OTHER STRONG OXIDIZING AGENTS CAN FORM EXPLOSIVE TYPE REACTIONS WHEN MIXED WITH ION EXCHANGE RESINS.

AZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
ACRYLIC MONOMER, DIVINYLBENZENE

CONTINUED ON NEXT PAGE

V – REACTIVITY INFORMATION

STABILITY	CONDITIONS TO AVOID
[X] STABLE [ ] UNSTABLE	Temperatures over 200C/392F.

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may yield styrene monomer, divinylbenzene, alkylamines and oxides of sulfur and nitrogen.

HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
[ ] MAY OCCUR [X] WILL NOT OCCUR	None known

INCOMPATIBILITY (MATERIALS TO AVOID): [ ] WATER [X] OTHER — Avoid contact with concentrated nitric acid or any other strong oxidizing agent at all times.

VI – SPILL OR LEAK PROCEDURE INFORMATION

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Floor may be slippery. Use care to avoid falls. Sweep up and transfer to containers for recovery or disposal.

WASTE DISPOSAL METHODS: Unused resin may be incinerated or landfilled in facilities meeting local, state and federal regulations. For contaminated resin, the user must determine the hazard and use an appropriate disposal method.

VII – SPECIAL PROTECTION INFORMATION

VENTILATION TYPE

Normal room ventilation.

RESPIRATORY PROTECTION

None required for normal operations.

PROTECTIVE GLOVES	EYE PROTECTION
None required	Safety glasses (ANSI Z-87.1 or approved equivalent)

OTHER PROTECTIVE EQUIPMENT

Eyewash facility

VIII – STORAGE AND HANDLING INFORMATION

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. 49C/120F MIN. 0C/32F	YES	NO	NO	YES

NOTE: Store at ambient temperatures. Avoid repeated freeze-thaw cycles.

NOTE: Ground ion exchange resins should be treated as potential eye irritants. A finely ground form of a structurally related strong acid cation exchange resin produced severe rabbit eye irritation.

NOTE: The maximum operating temperature for this product is 60C/140F. Functional group destruction and loss of capacity will occur above this temperature.

IX – TOXICITY INFORMATION

No toxicity data available for this product.

X – MISCELLANEOUS INFORMATION

Caution: Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this expansion can cause a glass column to shatter.

Caution: Nitric acid and other strong oxidizing agents can cause explosive-type reactions when mixed with ion exchange resins. Proper design of equipment to prevent rapid build-up of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange beads, consult sources knowledgeable in handling these materials.

NA = NOT APPLICABLE C = CEILING VALUE	KEY	DATE OF ISSUE	SUPERSEDES
	891090-3	11/08/88	09/04/87

APPENDIX F

Document #: 80278
Revision:
Date Released: 4-28-92

UNIBED SORBENT SIZING CALCULATIONS

OF THE DEIODINATION UNIBED USED IN

THE BREADBOARD CATALYTIC OXIDATION SYSTEM

FOR THE

NASA-MSFC PHASE II SBIR:

CATALYTIC METHODS USING MOLECULAR OXYGEN FOR

TREATMENT OF PMMS AND ECLSS WASTE STREAMS

Prepared By: _____

Approved By: James Akse Date: 4-28-92

Approved By: _____ Date: 4.28.92

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

1.0 INTRODUCTION

This document presents the design for the catalytic oxidation system's Deiodination Unibed. The ersatz humidity condensate being treated by the catalytic oxidation system my contain residual iodine for microbial control in addition to the other constituents given in Table 1. This iodine will impair the performance of the catalyst for oxidation of low molecular weight, polar nonionic organic species, and consequently it must be removed. The removal of both iodine and iodide from the system's influent is accomplished by this bed. The Deiodination Unibed should be installed immediately upstream of the catalytic oxidation system's inlet. (see Figure 1)

1.1 Application Documents

1.1.1 SBIR Phase II Contract NAS8-38490

1.2 Application Drawings

1.2.1 Umpqua Research: URC DWG 90209

1.3 General Approach

The design is based on (1) isotherm data from shaker table and small column single contaminant, single media tests performed at UMPQUA under the following NASA contracts: NAS9-17073, NAS9-17464, NAS9-17523, and NAS9-17611 and (2) manufacturer's stated ion exchange capacity.

Table 1

ERSATZ HUMIDITY CONDENSATE

Organics

	mg/liter	TOC (mg/liter)
Caprylic Acid	0.537	0.358
n-Dibutylamine	7.28	5.412
Dimethyl Phthalate	0.548	0.339
Ethanol	14.00	7.300
Formic Acid	1.65	0.431
Isopropanol	0.87	0.522
Lactic Acid	0.93	0.372
Methanol	1.54	0.577
Propanoic Acid	0.871	0.424
Thiourea	14.56	2.298
	42.79 mg/liter	18.03 mg/liter

Inorganics

Ammonium Hydroxide	36.3
Ammonium Phosphate	0.53
Ammonium Sulphate	0.25
Calcium Chloride	0.15
Sodium Chloride	0.36
Sodium Fluoride	0.49
Sodium Nitrate	0.36
	38.44 mg/liter

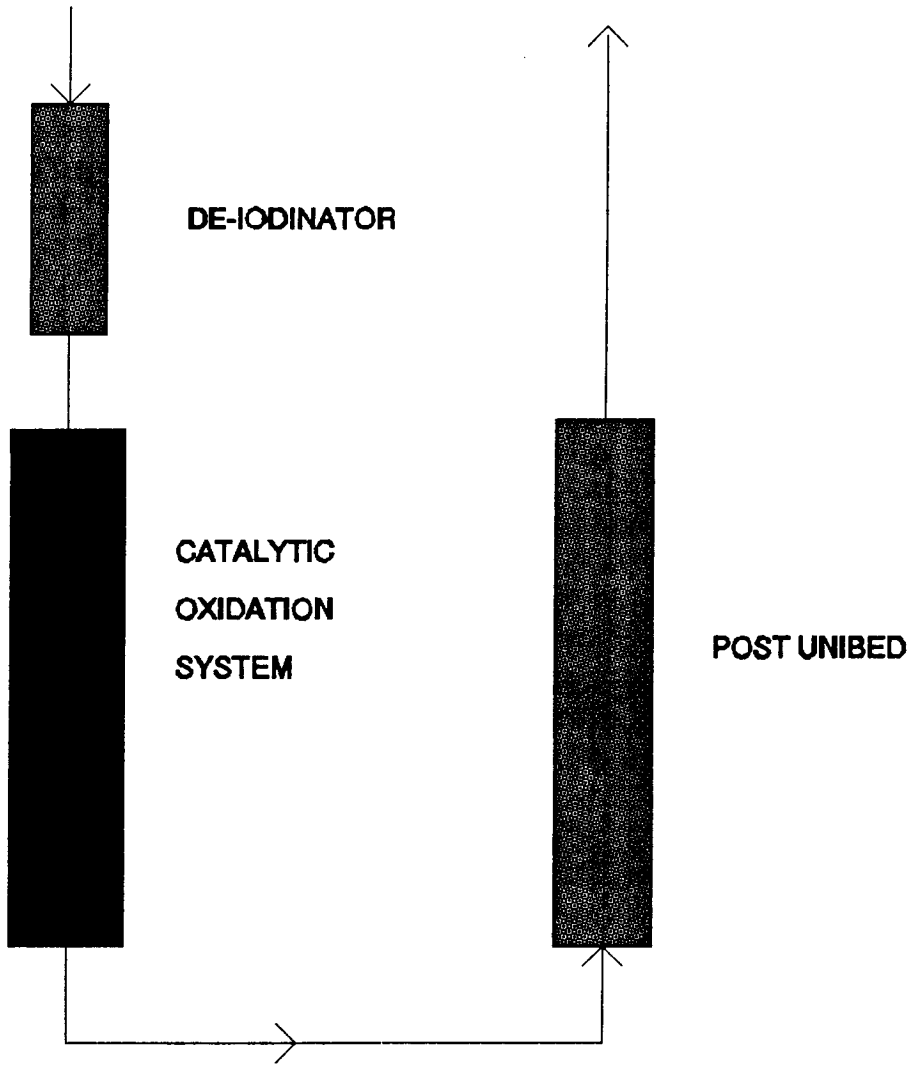


FIGURE 1

BED LOCATION

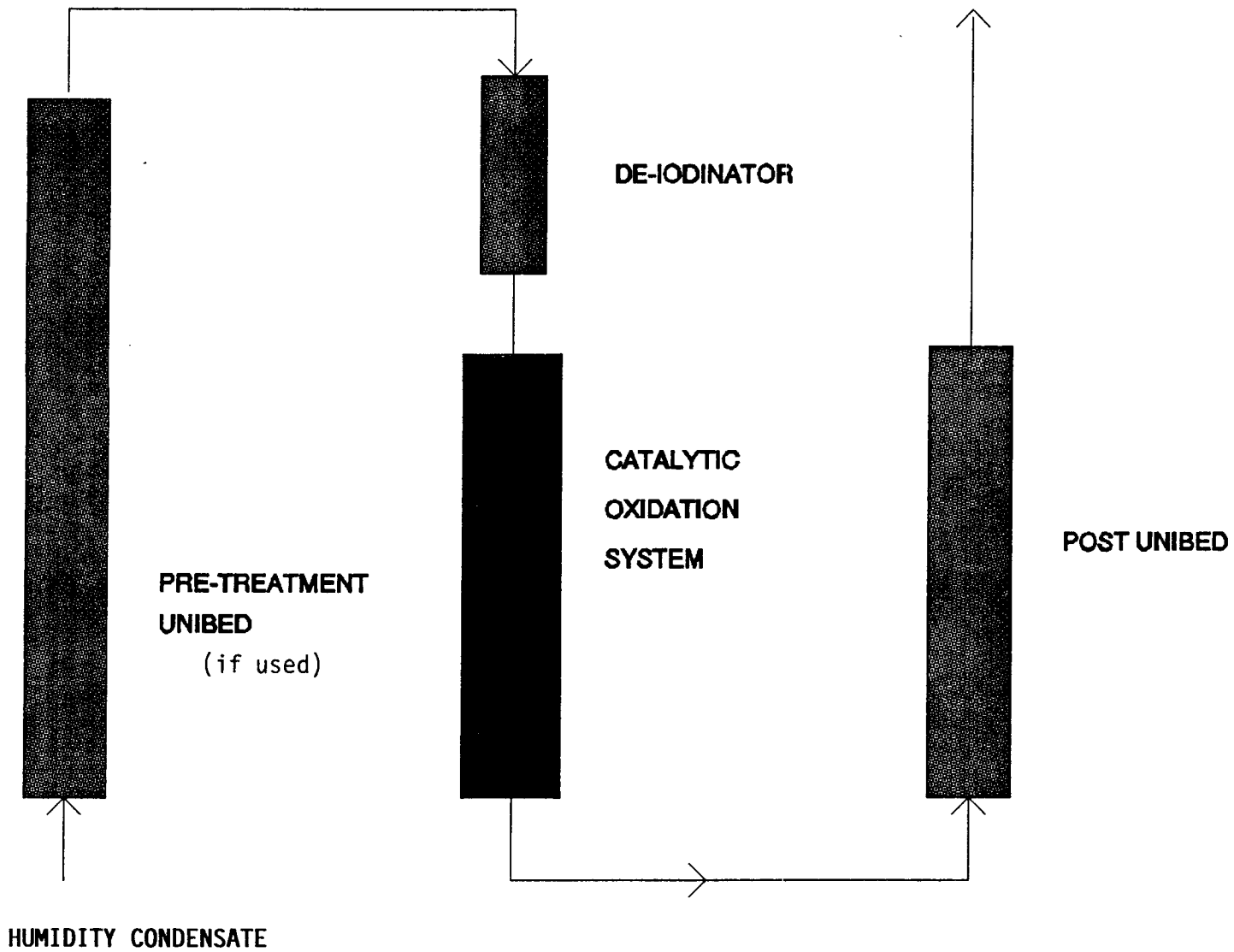


FIGURE 2
BED LOCATION

2.0 DEIODINATOR DESIGN REQUIREMENTS

2.1 Configuration

2.1.1 One 5 in long, 2 in diameter stainless steel tube with inner teflon coating and 1/8 " pipe thread elbows at the inlet.

2.2 Life at Design Conditions

2.2.1 Throughput: 2376 L

2.2.2 Time: 165 days

2.3 Inlet Solution

2.3.1 Iodinated Humidity Condensate Influent or Iodinated Pretreated Humidity Condensate (Table 1)

2.4 Flow

2.4.1 Flow Rate: 10 mL/min ≈ 0.6 L/hr

2.4.2 Daily Operating Time: 24 hr/day

2.4.3 1-Day Throughput: 14.4 L

2.5 Temperature

2.5.1 Operating Range: 68 - 77 F

2.6 Pressure

2.6.1 Maximum Operating Pressure (MOP): 40 psig

2.6.2 Proof Pressure: 60 ± 5 psig

2.7 Pressure Drop

2.7.1 Maximum Allowable Pressure Drop: 5 psig

2.8 Iodine Output

2.7.1 Range: <0.1 ppm

TABLE 2. DEIODINATION UNIBED SORBENTS

CONTAMINANT	MEDIA	MFG's' CAPACITY (meq/cm^3)	URC DESIGN CAPACITY (mg/cm^3)	SWELLING %
Iodine	SBR	0.83	209.7	-20
Iodine	IRN 150	0.73	158	-20

* * * * * * * * * * *

TABLE 3. DEIODINATION UNIBED MEDIA CONFIGURATION

Flow Direction	Sorbent	Ref. Para	Volume (cm^3)	Function
↓	SBR (½I^-, ½ OH form)	4.2.1	60	Iodine Removal
	IRN 150	4.2.2	60	Iodine Removal, pH Adjustmt

3.0 DEIODINATOR DESIGN DATA

The design data were developed by UMPQUA under contract to NASA-JSC for the ion exchange and MCV media (see paragraph 1.3 for applicable contract numbers).

3.1 Sorbent Selection

The best performing media have been selected based on single sorbent-single contaminant/shaker table and single sorbent-single contaminant/dynamic column tests run previously by UMPQUA. The selected sorbents are listed in Table 2.

3.2 Adsorption Equilibrium Data

Table 2 contains ion exchange loadings (equilibrium data) necessary for the design of the sorption sub-beds. These data are from UMPQUA small-column tests and are lower than the manufacturer's published values.

4.0 DEIODINATOR UNIBED DESIGN

4.1 Deiodinator Unibed Dimensions

The unibed consists of a single 2 in x 5 in long stainless steel housing containing nominally, 120 cc of media. The total bed length is 2.33 in. A sub-bed volume of 60 cc provides the minimum bed length to diameter ratio necessary to insure proper flow characteristics. The remaining volume is occupied by lip seals, an internal spring and the end caps.

4.2 Deiodinator Unibed Configuration and Sub-bed Sizing

The configuration of the deiodination Unibed is shown in Table 3. The initial SBR sub-bed functions to remove iodine.

This removal is a requirement for the catalytic oxidation system downstream of this Unibed whose catalyst is poisoned by the presence of iodine. The IRN 150 sub-bed also functions to remove iodine, and secondarily to neutralize the effluent's pH by the activity of both cation and anion exchange resins. The sizing rationale for each sub-bed is presented in the following paragraphs.

4.2.1 SBR

Feed water to the deiodination Unibed has an iodine residual of 0.5 to 4.0 ppm.

Total Sorption Capacity:

60 cm^3 SBR x 209.7 mg/cm^3 = 12,582 mg I_2; I_2 values range between 0.5 and 4 ppm.

Throughput Capacity: 12,564 mg ÷ 4 mg/L = 3146 L

Life: 2094 L ÷ 14.4 L/day = 218 days

4.2.2 IRN 150

The effluent from the SBR sub-bed contains iodine and minor amounts of bases such as potassium or sodium hydroxide. The primary function will be to remove iodine.

Total Sorption Capacity:

60 cm^3 IRN 150 x 158 mg/cm^3 = 9,480 mg I_2

Throughput Capacity: 9,480 mg ÷ 4 mg/L I_2= 2370 L

Life: 1580 L ÷ 14.4 L/day = 165 days

4.2.3 Sizing Discussion

The design summarized in Table 3 was obtained within the dimension restraints in Paragraph 4.1. The capacity is limited by the overall bed size. The effluent pH conditioning requirements depend on the concentration of alkali and transition metal iodide species present in the IRN-150 influent. These are expected to be quite low if feed is from the Unibed. If feed is just Iodinated humidity condensate then I^- levels could be quite high. So the limiting factor in the lifetime of the Unibed is the iodine capacity of the two sub-beds.

4.3 Pressure Drop

Previous testing developed a pressure drop equation.

$$\delta P = 0.4\ WL\ \mu/D^2$$

where:

δP = Pressure drop, psi

W = flow rate, lb/min

L = bed length, in

D = bed diameter, in

μ = viscosity, centipoise

For the Deiodinator bed:

W = 1.32 lb/hr = 0.022 lb/min

L = 2.33 in

D = 2 in

μ = 1 centipoise

$$\delta P = 0.4\ (0.022)(2.33)(1)/(2)^2 = 0.005 \text{ psi}$$

Specified max δP = 5.0 psi

4.4 Summary of Unibed Design Values

A summary of the design values for the beds is given in Table 4.

TABLE 4. SUMMARY OF
DEIODINATION UNIBED DESIGN VALUES

Parameter	Value
URC Drawing Number	90209
Nominal ID	2 in
Water System	Potable
Flow Rate	1.32 lb/hr (0.6 L/hr)
Daily Operating Time	24 hr/day
Thruput, 1 day	14.4 L
Total Media volume	120 cc
Cross Sectional Area	20.3 cm^2
Total Length of Media (Installed)	2.33 in
Face Velocity	0.493 cm/min
Empty Bed Contact Time	12 min
Life (limited by IRN-150)	2376 L, 165 days

APPENIDIX I

MEDIA INFORMATION

ION ± EXCHANGE

applications • recommendations • materials

T. D. Index 220.01

DOWEX SBR anion exchange resin

DOWEX® SBR anion exchange resin is a strongly basic, Type I resin, based on a stable styrene-divinylbenzene copolymer matrix with quarternary ammonium functional groups. This is a general purpose anion exchange resin that is used in all types of deionization systems. Of all strongly basic anion exchange resins, DOWEX SBR resin is the most stable to chemical and physical degradation.

APPLICATIONS

Deionization – DOWEX SBR resin is used in multiple bed and mixed bed deionization equipment on all types of water. It is especially recommended for waters having a high percentage of weak anions such as silica and carbon dioxide. In addition to a high capacity for silica, DOWEX SBR resin has the stability to allow high regeneration temperatures which yield minimum silica leakage.

Nuclear Applications – DOWEX SBR nuclear grade resin plays an important part in the chemistry of nuclear power systems. It is essential in the preparation of high purity water, control and purification of coolant, reduction of corrosion, decontamination, and purification of condensate.

Condensate Polishing – High flowrate systems utilize mixed beds of DOWEX HGR-W and DOWEX SBR resins to purify condensates for use in high pressure boiler systems. Control of particle size and uniformity results in low pressure losses. Anti-clump treatment gives faster, cleaner separations. The inherent capacity and regeneration efficiency insures reserve operating capacity.

DOWEX SBR resin meets the requirements of Food Additive Regulation 173.25.

PHYSICAL AND CHEMICAL PROPERTIES

Capacity

DOWEX SBR anion exchange resin is a high capacity resin. Because of the basicity and stability of the resin, DOWEX SBR resin maintains its salt splitting capacity for longer periods of time than other anion resins.

Basicity

DOWEX SBR resin is comparable to sodium hydroxide in basicity and will form stable bonds with any anion. It is highly recommended for the removal of weakly ionized anions, especially silica.

Stability

The crack-free, transparent beads of DOWEX SBR resin provide superior physical stability under severe operating conditions. Its quaternary ammonium groups provide maximum resistance to oxidation and other degrading conditions, such as caustic soda regeneration at high temperatures.

WARNING: Oxidizing agents such as nitric acid attack organic Ion Exchange resins under certain conditions and could result in a slightly degraded resin up to an explosive reaction.

Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

Hydraulic Characteristics

Like all DOWEX resins, the particle size of DOWEX SBR resin is carefully controlled to give a more uniform bead size with minimum fines and large beads. This results in low pressure drop in service and good separation and mixing in mixed bed operations.

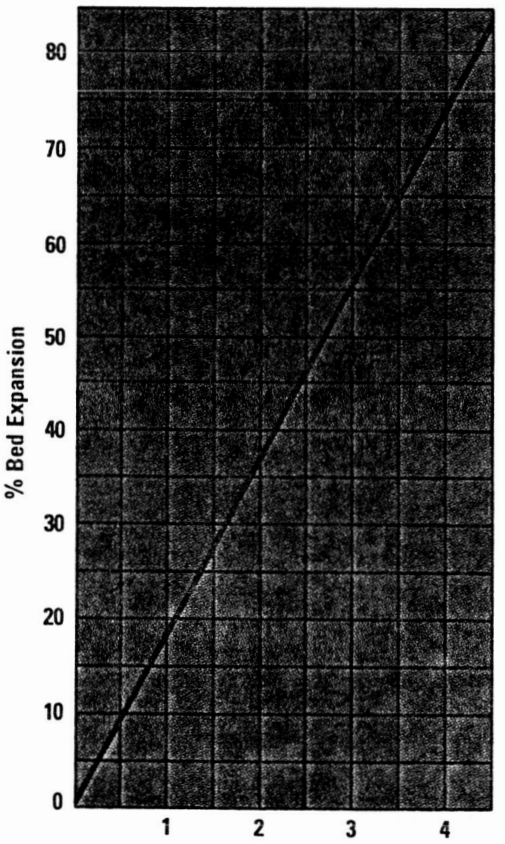
Physical form	Hard, cream colored spheres
Sphericity	90% min.
Shipping weight	44 lbs./cu. ft.
Water retention capacity	43-48%
Standard screen size	20-50 mesh (wet)
On 16 mesh	5% max.
Through 50 mesh	3% max.
Color throw, APHA no.	20 max.
Minimum Total Capacity	Cl Form
Meq/g dry resin	3.5
Meq/ml wet resin	1.4
Kgr/cu. ft. at $CaCO_3$	30.0

THE DOW CHEMICAL COMPANY
AN OPERATING UNIT OF THE DOW CHEMICAL COMPANY
SPECIALTY PRODUCTS DEPARTMENT • MIDLAND, MICHIGAN 48640

SUGGESTED OPERATING CONDITION

pH Range	0-14
Maximum Temperature:	
Hydroxyl Form	122°F
Chloride Form	210°F
Minimum Bed Depth	30 inches
Service Flow Rate	2 gpm/cu. ft. (see Fig. 5)
Backwash Flow Rate	Sufficient to produce at least 50-75% expansion in bed volume. (see Fig. 1)
Regenerant Level	Dependent on capacity and leakage desired (see Fig. 2, 3 and 4)
Regenerant Concentration	4% NaOH
Regenerant Temperature	Ambient (120°F for silica)
Regenerant Injection Time	5 lbs./cu. ft./hr.
Displacement Rinse	0.25 gpm/cu. ft.
Final Rinse	1 gpm/cu. ft
Rinse Water Requirement	50 gals./cu. ft.

FIGURE 1 — Bed Expansion of DOWEX SBR Resin



Wet Screen Mesh	(Typical) %
+16	0.1
+20	2.3
+30	52.4
+35	14.8
+40	3.2
+50	1.2
−50	0.0

To determine Backwash Flow Rate at temperature t

$F_1 = F_{77} [1 + .008 (t - 77)]$

FIGURE 2 — Operating Exchange Capacity of DOWEX SBR

(120°F Regenerating Temperature; 77°F Operating Temperature)

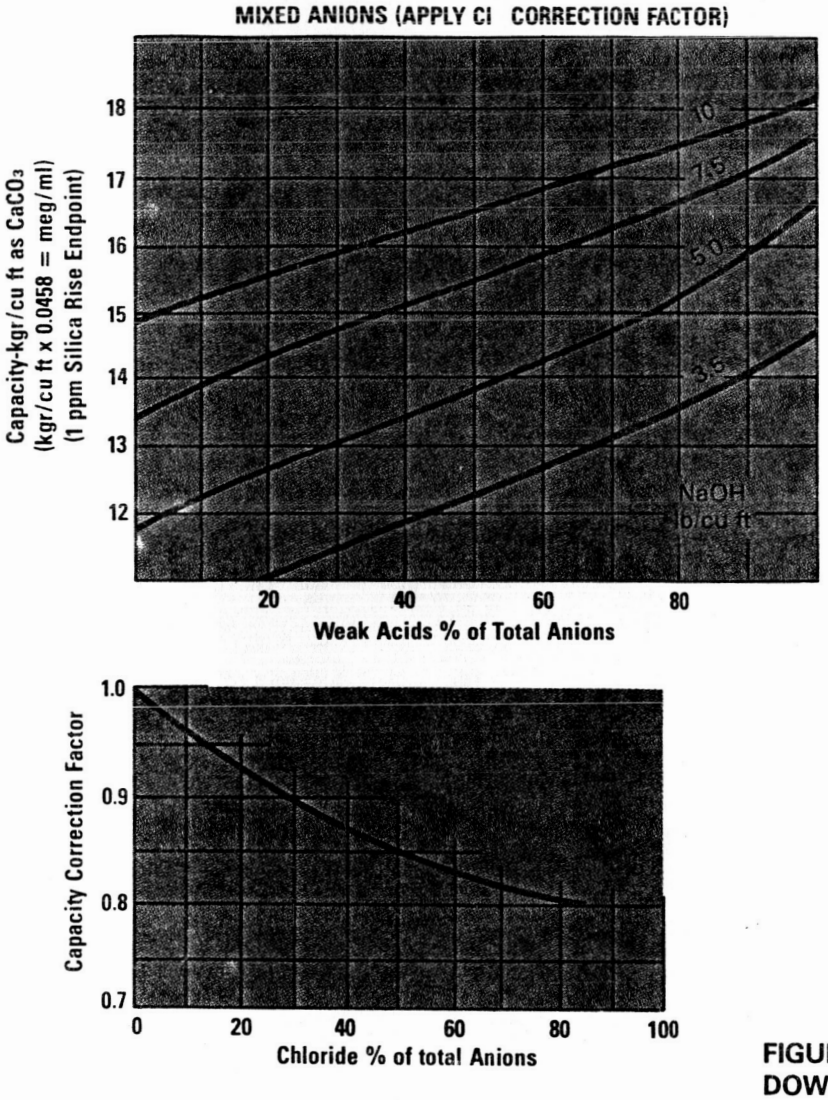
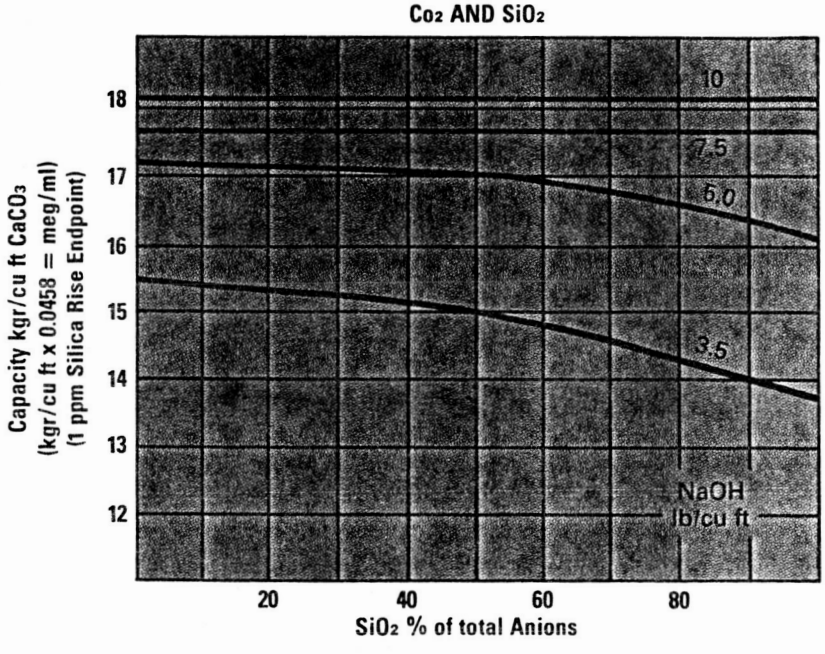


FIGURE 3 — Operating Exchange Capacity of DOWEX SBR Resin — Co_2 and SiO_2 Only

(120°F Regenerating Temperature; 77°F Operating Temperature)



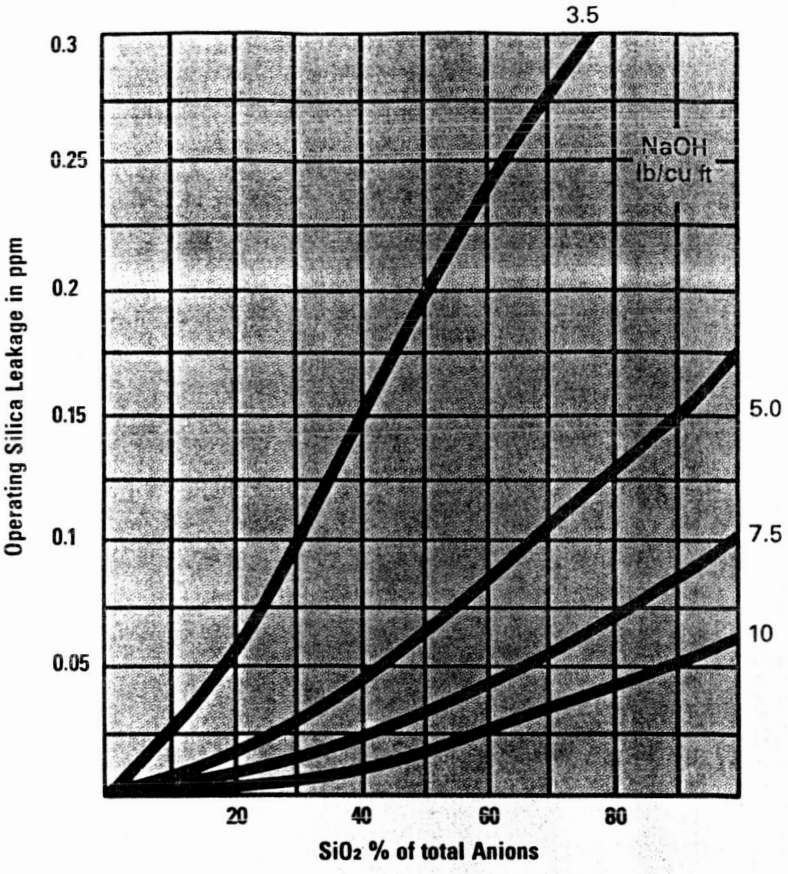
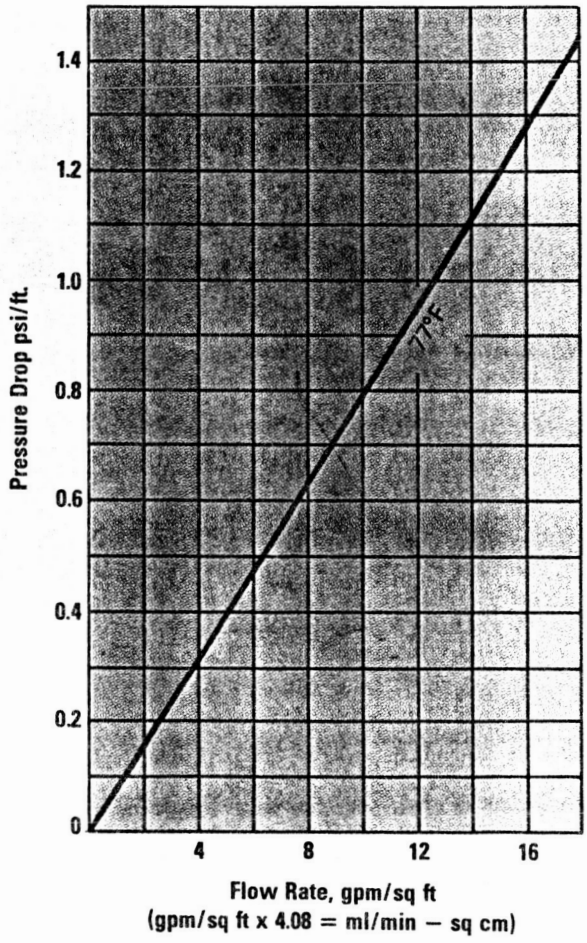


FIGURE 4 — Operating Silica Leakage for DOWEX SBR Resin
(120°F Regenerating Temperature 77°F Operation)

Wet Screen Mesh	(Typical) %	To Find Pressure Drop at other Temperatures, Multiply Pressure Drop at 77°F by Factor	
		t (°F)	Factor
+16	0.1		
+20	28.3	35	1.89
+30	52.4	45	1.51
+35	14.8	55	135
+40	3.2	65	1.16
+50	1.2	90	0.84
−50	0.0	120	0.62

FIGURE 5 — Pressure Drop with DOWEX SBR Resin



THE DOW CHEMICAL COMPANY
AN OPERATING UNIT OF THE DOW CHEMICAL COMPANY
SPECIALTY PRODUCTS DEPARTMENT • MIDLAND, MICHIGAN 48640

in U.S.A. CC 21829 Form No. 177-1128-83

ROHM AND HAAS COMPANY
PHILADELPHIA, PENNSYLVANIA 19105
FLUID PROCESS CHEMICALS

AMBERLITE ION EXCHANGE RESINS

AMBERLITE® IRN-150

ION EXCHANGE RESIN

Amberlite IRN-150 is a mixture of gelular, polystyrene cation and anion exchange resins. Amberlite IRN-150 resin as supplied contains a stoichiometric equivalent of the strongly acidic cation (Amberlite IRN-77) and the strongly basic anion (Amberlite IRN-78) exchange resins. It is supplied in the hydrogen/hydroxide form as clear, amber colored spherical particles virtually perfect in bead appearance. Amberlite IRN-150 resin is designed for use in industrial water treatment applications, particularly in once through applications such as primary water chemistry control in nuclear power operations. This resin combines the properties of high capacity and excellent resistance to bead fracture from attrition or osmotic shock.

Amberlite IRN-150 resin is designated as a Nuclear Grade resin and is manufactured using special processing procedures. These procedures, combined with a patented Rohm and Haas process to reduce the chloride content of the anion component, produce material of the ultimate purity and yield a product meeting the exacting demands of the nuclear industry. Amberlite IRN-150 resin is recommended in any non-regenerable mixed bed application where reliable production of the highest quality water is required and where the "as supplied" resin must have an absolute minimum of ionic and non-ionic contamination.

IMPORTANT FEATURES OF AMBERLITE IRN-150 ION EXCHANGE RESIN

HIGH CAPACITY: Amberlite IRN-150 resin will exhibit a nominal operating capacity of 12 kg/ft³ (0.55 meq/ml).

EXCEPTIONAL PURITY: Amberlite IRN-150 resin is manufactured to demanding purity specifications which assure a minimum of ionic and non-ionic contamination.

GOOD RESISTANCE TO BEAD FRACTURE: Amberlite IRN-150 resin offers superior performance with respect to particle breakdown from attrition or osmotic shock.

INSOLUBLE IN ALL COMMON SOLVENTS

RECOMMENDED CONDITIONS OF OPERATION

The recommended conditions for operation of Amberlite IRN-150 resin are listed below.

BED DEPTH: 24" minimum (0.61 m)

SERVICE FLOW RATE: 2–5 gpm/ft³ (16 to 40.1 l/hr/l)

PHYSICAL CHARACTERISTICS

SHAPE: Spherical beads

SHIPPING WEIGHT: 43 lbs/ft³ (688 g/l)

PARTICLE SIZE (U.S. MESH):

Screen Size	% Maximum
+16	5.0
−40	5.0
−50	0.5

PERFECT BEADS: 95% minimum

CHEMICAL CHARACTERISTICS

IONIC FORM: Hydrogen/Hydroxide

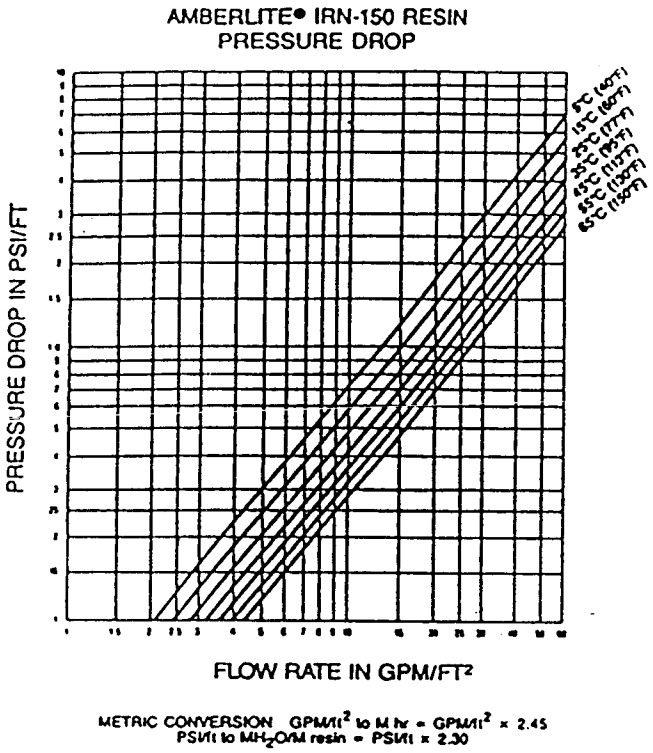
CATION TO ANION EQUIVALENT RATIO: 1:1

Ionic Content by Individual Component:	IRN-77	IRN-78
Equivalent % H, minimum	99.0	na
Equivalent % OH, minimum	na	95.0
Equivalent % Cl, maximum	na	0.10
Equivalent % CO_3, maximum	na	5.0
Equivalent % SO_4, maximum	na	0.10
Sodium (ppm dry resin) maximum	50	50
Iron (ppm dry resin) maximum	50	50
Copper (ppm dry resin) maximum	10	10
Heavy metals as Pb (ppm dry resin) maximum	10	10
Aluminum (ppm dry resin) maximum	50	50
Calcium (ppm dry resin) maximum	50	50
Magnesium (ppm dry resin) maximum	50	50

HYDRAULIC CHARACTERISTICS

PRESSURE DROP: The approximate pressure drop for each foot of ed depth of Amberlite IRN-150 resin in normal down flow peration at various temperatures and flow rates is shown in the raph below.

ESIN HANDLING: To retain the high purity standards of uclear grade resins, deionized water should be used for all esin handling. Contact of the resin with air should also be inimized to avoid CO_2 pickup and subsequent loss of capacity f the anion resin.



METRIC CONVERSION GPM/ft² to M hr = GPM/ft² x 2.45
PSI/ft to MH₂O/M resin = PSI/ft x 2.30

APPLICATIONS

MIXED BED DEIONIZATION: The physical and chemical characteristics of Amberlite IRN-150 resin provide excellent performance when used in production of high quality water in any mixed bed deionization application.

NUCLEAR APPLICATIONS: The purity and physical stability of Amberlite IRN-150 resin provides unsurpassed performance in nuclear applications such as chemistry control in primary water treatment. Amberlite IRN-150 resin can also be used for a variety of rad waste applications.

PRODUCTION OF ULTRA PURE WATER: Amberlite IRN-150 resin is an excellent choice for once through (non-regenerable) applications typically found in the final DI water processing for the semiconductor industry. Amberlite IRN-150 resin provides rapid rinse to 18 megohm, high capacity, and reliable production of the highest-quality water.

SAFE HANDLING INFORMATION

A Material Safety Data Sheet is available for Amberlite IRN-150 resin. To obtain a copy, contact your Rohm and Haas representative.

CAUTION: Acidic and basic regenerant solutions are corrosive and should be handled in a manner that will prevent eye and skin contact.

Nitric acid and other strong oxidizing agents can cause explosive type reactions when mixed with ion exchange resins. Proper design of process equipment to prevent rapid buildup of pressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. Before using strong oxidizing agents in contact with ion exchange resins, consult sources knowledgeable in the handling of these materials.

APPENDIX II

MATERIAL SAFETY DATA SHEETS

MATERIAL SAFETY DATA SHEET

Dow Chemical U.S.A.* Midland, MI 48674 Emergency Phone: 517-636-4400

PRODUCT NAME: DOWEX (R) SBR NUCLEAR GRADE, OH ANION EXCHANGE RESIN

Effective Date: 01/17/90 Date Printed: 03/14/90 MSDS:003608

1. INGREDIENTS: (% w/w, unless otherwise noted)

Trimethylamine functionalized, chloromethylated copolymer of styrene and divinylbenzene in in the hydroxide form.	CAS# 069011-18-3	40-70%
Water	CAS# 007732-18-5	

This document is prepared pursuant to the OSHA Hazard Communication Standard (29 CFR 1910.1200). In addition, other substances not 'Hazardous' per this OSHA Standard may be listed. Where proprietary ingredient shows, the identity may be made available as provided in this standard.

2. PHYSICAL DATA:

BOILING POINT: Not applicable
VAP PRESS: Not applicable
VAP DENSITY: Not applicable
SOL. IN WATER: Insoluble
SP. GRAVITY: Density 41 lb/ft3
APPEARANCE: White to dark amber solid (beads).
ODOR: Amine odor.

3. FIRE AND EXPLOSION HAZARD DATA:

FLASH POINT: Not applicable
METHOD USED: Not applicable

FLAMMABLE LIMITS
LFL: Not applicable
UFL: Not applicable

EXTINGUISHING MEDIA: Dry chemical.

FIRE & EXPLOSION HAZARDS: Product is not combustible until

(Continued on Page 2)
(R) Indicates a Trademark of The Dow Chemical Company

* An Operating Unit of The Dow Chemical Company

3. FIRE AND EXPLOSION HAZARD DATA: (CONTINUED)

moisture is removed, then resin starts to burn in flame at 230C. Autoignition occurs above 500C. Hydrochloric acid, naphthalene, benzaldehydes, phenol, carbon dioxide, water, organic amines, chlorine, nitrogen oxides, ammonia, methyl chloride, may be emitted during combustion.

FIRE-FIGHTING EQUIPMENT: Wear positive pressure self-contained breathing apparatus.

4. REACTIVITY DATA:

STABILITY: (CONDITIONS TO AVOID) Stable under normal handling and storage conditions. See incompatibility statement.

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Warning: Oxidizing agents such as nitric acid attack organic ion exchange resin under certain conditions and could result in a slightly degraded resin up to an explosive reaction. Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

HAZARDOUS DECOMPOSITION PRODUCTS: See possible combustion products in section 3.

HAZARDOUS POLYMERIZATION: Will not occur.

5. ENVIRONMENTAL AND DISPOSAL INFORMATION:

ACTION TO TAKE FOR SPILLS/LEAKS: Sweep up. Caution: May be slippery.

DISPOSAL METHOD: Bury resin in licensed landfill, or burn in approved incinerator according to local, state, and federal regulations. For resin contaminated with hazardous material, dispose of mixture as hazardous material according to local, state, and federal regulations.

(Continued on Page 3)

6. HEALTH HAZARD DATA:

EYE: May cause severe eye irritation. May cause moderate corneal injury. Effects are likely to heal.

SKIN CONTACT: Prolonged or repeated exposure may cause skin irritation.

SKIN ABSORPTION: Skin absorption is unlikely due to physical properties.

INGESTION: Single dose oral LD50 has not been determined. Single dose oral toxicity is believed to be low. No hazards anticipated from ingestion incidental to industrial exposure.

INHALATION: Vapors are unlikely due to physical properties.

SYSTEMIC & OTHER EFFECTS: No specific data available, however, repeated exposures are not anticipated to cause any significant adverse effects.

7. FIRST AID:

EYES: Irrigate with flowing water immediately and continuously for 15 minutes. Consult medical personnel.

SKIN: Wash off in flowing water or shower.

INGESTION: No adverse effects anticipated by this route of exposure incidental to proper industrial handling.

INHALATION: No adverse effects anticipated by this route of exposure.

(Continued on Page 4)

8. HANDLING PRECAUTIONS:

EXPOSURE GUIDELINE(S): None established.

VENTILATION: Good general ventilation should be sufficient.

RESPIRATORY PROTECTION: No respiratory protection should be needed.

SKIN PROTECTION: No precautions other than clean body-covering clothing should be needed.

EYE PROTECTION: Use chemical goggles.

9. ADDITIONAL INFORMATION:

REGULATORY REQUIREMENTS:

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA 'Hazard Categories' promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard

SPECIAL PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Practice reasonable care and caution. Metal equipment should be compatible with feed, regenerant, resin form, and effluent of that process.

TSCA CONSIDERATIONS:
Every different salt or ionic form of an ion-exchange resin is a separate chemical. If you use an ion-exchange resin for ion-exchange purposes and then remove the by-product resin from its vessel or container prior to recovery of the original or another form of the resin or of another chemical, the by-product resin must be listed on the TSCA Inventory (unless

(Continued on Page 5)

9. ADDITIONAL INFORMATION: (CONTINUED)

an exemption is applicable). It is the responsibility of the customer to ensure that such isolated, recycled by-product resins are in compliance with TSCA. Failure to comply could result in substantial civil or criminal penalties being assessed by the Environmental Protection Agency.

MSDS STATUS: New.

ROHM AND HAAS COMPANY

CORPORATE PRODUCT INTEGRITY DEPARTMENT
INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19105

EMERGENCY TELEPHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING
4=EXTREME
3=HIGH
2=MODERATE
1=SLIGHT
0=INSIGNIFICANT
**=SEE SECTION IV

FIRE TOXICITY REACTI SPECIAL

1 1 0

BS242
LIST 7

MATERIAL SAFETY DATA SHEET

NOT OSHA HAZARDOUS
NOT WHMIS CONTROLLED

MATERIAL	CODE	KEY	DOT HAZARD CLASS
AMBERLITE® IRN-150 Resin	69855	891090-3	NON-REGULATED
	DATE ISSUED 11/08/88		

FORMULA	CHEMICAL NAME OR SYNONYMS
Not applicable	Mixed bed ion exchange resin (hydrogen and hydroxide forms)

I – COMPOSITIONAL INFORMATION

	CAS Reg. No.	APPROX WT %	TWA/TLV R&H	OSHA	ACGIH
Anion/cation exchange resin	NONHAZ	35-50	NE	NE	NE
Water	NONHAZ	50-65	NE	NE	NE

NE = None established

II – PHYSICAL PROPERTY INFORMATION

APPEARANCE · ODOR · pH.			VISCOSITY
Beads; pH (aqueous slurry) = 5 to 9			NA
MELTING OR FREEZING POINT	**BOILING POINT**	**VAPOR PRESSURE (mm Hg)**	**VAPOR DENSITY (AIR=1)**
0C/32F (water)	100C/212F (water)	17 @20C (water)	Less than 1 (water)
SOLUBILITY IN WATER	**PERCENT VOLATILE (BY WEIGHT)**	**SPECIFIC GRAVITY (WATER=1)**	**EVAPORATION RATE (BUTYL ACETATE=1)**
Negligible	50-65 (water)	1.1-1.3	Less than 1 (water)

III – FIRE AND EXPLOSION HAZARD INFORMATION

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT (%)	UPPER EXPLOSION LIMIT (%)
NA	500C/932F (est.)	NA	NA

EXTINGUISHING MEDIA

☐ FOAM ☐ "ALCOHOL" FOAM ☒ CO_2 ☒ DRY CHEMICAL ☒ WATER SPRAY ☐ OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear self-contained breathing apparatus (pressure-demand, MSHA/NIOSH-approved or equivalent) and full protective gear.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Toxic combustion products may include alkylamines and oxides of sulfur and nitrogen.

IV – HEALTH HAZARD INFORMATION

ROHM AND HAAS RECOMMENDED WORK PLACE EXPOSURE LIMITS

STEL = None established.

EFFECTS OF OVEREXPOSURE

Eye Contact: Product can cause eye irritation.

EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: Immediately flush eyes with large amounts of water and continue for at least 15 minutes. Get prompt medical attention.

V – REACTIVITY INFORMATION

ABILITY
[X] STABLE [ ] UNSTABLE

CONDITIONS TO AVOID
Temperatures over 200C/392F.

ZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition may yield styrene monomer, divinylbenzene, lkylamines and oxides of sulfur and nitrogen.

ZARDOUS POLYMERIZATION
[ ] MAY OCCUR [X] WILL NOT OCCUR

CONDITIONS TO AVOID
None known

COMPATIBILITY (MATERIALS TO AVOID) Avoid contact with concentrated nitric acid or any other strong oxidizing agent at all times.
[ ] WATER [X] OTHER

VI – SPILL OR LEAK PROCEDURE INFORMATION

EPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
oor may be slippery. Use care to avoid falls. Sweep up and transfer to containers for ecovery or disposal.

ASTE DISPOSAL METHODS Unused resin may be incinerated or landfilled in facilities meeting local, ate and federal regulations. For contaminated resin, the user must determine the hazard and e an appropriate disposal method.

VII – SPECIAL PROTECTION INFORMATION

NTILATION TYPE
rmal room ventilation.

SPIRATORY PROTECTION
ne required for normal operations.

OTECTIVE GLOVES
ne required

EYE PROTECTION
Safety glasses (ANSI Z-87.1 or approved equivalent)

HER PROTECTIVE EQUIPMENT
ewash facility

VIII – STORAGE AND HANDLING INFORMATION

ORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
AX. 49C/120F MIN. 0C/32F	YES	NO	NO	YES

TE: Store at ambient temperatures. Avoid repeated freeze-thaw cycles.
TE: Ground ion exchange resins should be treated as potential eye irritants. A finely ound form of a structurally related strong acid cation exchange resin produced severe rabbit e irritation.
TE: The maximum operating temperature for this product is 60C/140F. Functional group estruction and loss of capacity will occur above this temperature.

IX – TOXICITY INFORMATION

o toxicity data available for this product.

X – MISCELLANEOUS INFORMATION

aution: Do not pack column with dry ion exchange resins. Dry beads expand when wetted; this xpansion can cause a glass column to shatter.
aution: Nitric acid and other strong oxidizing agents can cause explosive-type reactions hen mixed with ion exchange resins. Proper design of equipment to prevent rapid build-up of ressure is necessary if use of an oxidizing agent such as nitric acid is contemplated. efore using strong oxidizing agents in contact with ion exchange beads, consult sources nowledgeable in handling these materials.
MBERLITE® IS A TRADEMARK OF ROHM AND HAAS COMPANY OR ONE OF ITS SUBSIDIARIES OR AFFILIATES.

A • NOT APPLICABLE C • CEILING VALUE	KEY	DATE OF ISSUE	SUPERSEDES
	891090-3	11/08/88	09/04/87

V – REACTIVITY INFORMATION

TABILITY	CONDITIONS TO AVOID
[X] STABLE [ ] UNSTABLE	Temperatures over 200C/392F.

AZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition may yield styrene monomer, divinylbenzene, alkylamines and oxides of sulfur and nitrogen.

ZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
[ ] MAY OCCUR [X] WILL NOT OCCUR	None known

COMPATIBILITY (MATERIALS TO AVOID) Avoid contact with concentrated nitric acid or any other strong oxidizing agent at all times.
[ ] WATER [X] OTHER

VI – SPILL OR LEAK PROCEDURE INFORMATION

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VII – SPECIAL PROTECTION INFORMATION

NTILATION TYPE
ormal room ventilation.

SPIRATORY PROTECTION
one required for normal operations.

OTECTIVE GLOVES	EYE PROTECTION
one required	Safety glasses (ANSI Z-87.1 or approved equivalent)

HER PROTECTIVE EQUIPMENT
ewash facility

VIII – STORAGE AND HANDLING INFORMATION

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AX. 49C/120F MIN. 0C/32F	YES	NO	NO	YES

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	891090-3	11/08/88	09/04/87

NASA

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle

Catalytic Methods Using Molecular Oxygen for Treatment of PMMS & ECLSS Waste Streams

5. Report Date

May 1992

6. Performing Organization Code

URC

7. Author(s)

James R. Akse

8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address

Umpqua Research Company
PO Box 791
Myrtle Creek OR 97457

11. Contract or Grant No.

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13. Type of Report and Period Covered

Final Report
4/90 - 4/92

12. Sponsoring Agency Name and Address

National Aeronautics and Space Administration
Washington DC 20546-0001
Marshall Space Flight Center

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract Catalytic oxidation has proven to be an effective addition to the baseline sorption, ion exchange water reclamation technology which will be used on Space Station Freedom (SSF). Low molecular weight, polar organics such as alcohols, aldehydes, ketones, amides, and thiocarbamides which are poorly removed by the baseline multifiltration (MF) technology can be oxidized to carbon dioxide at low temperature (121 C). The catalytic oxidation process by itself can reduce the Total Organic Carbon (TOC) to below 500 ppb for solutions designed to model these waste waters. Individual challenges by selected contaminants has shown only moderate selectivity towards particular organic species. The combined technology is applicable to more complex waste water generated in the Process Materials Management System (PMMS) and Environmental Control and Life Support System (ECLSS) aboard SSF. During the Phase III Core Module Integrated Facility (CMIF) water recovery tests at NASA Marhsall Space Flight Center, real hygiene waste water and humidity condensate were processed to meet potable specifications by the combined technology. A kinetic study of catalytic oxidation demonstrates that the Langmuir-Hinshelwood rate equation for hetergeneous catalysts accurately represent the kinetic behavior. From this relationship, activation energy and rate constants for acetone oxidation were determined.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Catalytic oxidation, ultrapure water, aqueous phase, low temperature	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price